

# RCx 101

## A Technical Introduction to Existing Building Commissioning

Introduction



**Instructor:**

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Senior Engineer

Facility Dynamics Engineering

May 23, 2017

# Class Material Location

The slides and other supporting information for the class can be found at:

<http://www.av8rdas.com/pacific-energy-center-classes1.html#Current>

They will be there until the next class, at which time they will be relocated to the PEC Class materials link from my blog

About using my spreadsheets and other resources:

- They are my tools vs. tools I developed to be used by others
- Use at your own risk; I provide them as a resource for you to use as a starting point
- You still need to understand how it works and fix it if it doesn't work for you

# Disclaimer

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# Copyright Materials

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# Learning Objectives

**After completing this course you should be able to:**

- At the end of this session, participants will be able to:
  1. Demonstrate a basic understanding of the retrocommissioning process
  2. Identify the skills they need to develop or need to have brought to the table by a provider to perform commissioning work, especially retrocommissioning and ongoing commissioning work.
  3. Explain why the skills are important for a successful commissioning process.
  4. Describe resources that can be used to develop the key skills discussed in the presentation.

# Learning Objectives

After completing this course you should be able to:

- Bottom Line:

*Prepare yourself to participate in the next Existing Building Commissioning Workshop Starting in July.*

# Agenda

- Overview of the EBCx Workshop
- Introduction to Existing Building Commissioning and the 10 Skills
- A Closer Look at the 10 Skills
  - Focus on the skill you will need to start a project and/or start the EBCx Workshop Class
  - Look at how the skills build off of each other
  - Look at what you need to target as learning objectives for each skill
- Interactive Scoping Exercises

# Ten Key Retrocommissioning Skills

1. Be Able to Benchmarking and Perform Utility Analysis
2. Be able to Scope a Facility
3. Be Familiar with Fundamental Principles and HVAC
4. Understand and Apply the System Concept
5. Be Able to Perform Data Logging and Trend Analysis
6. Be Familiar with Functional Testing Techniques
7. Be Familiar with Data Analysis Techniques
8. Be Familiar with Basic HVAC and Energy Calculations
9. Be Familiar with Cost/Benefit and Return on Investment Calculations
10. Develop a Competency with Control Systems

# Ten Key Retrocommissioning Skills

1. Be Able to Benchmarking and Perform Utility Analysis
2. Be able to Scope a Facility
3. Be Familiar with Fundamental Principles and HVAC
4. Understand and Apply the System Concept
5. Be Able to Perform Data Logging and Trend Analysis
6. Be Familiar with Functional
7. Be Familiar with Fundamental Principles:
  1. Loads
  2. Centrifugal Machines
  3. Piping Systems
  4. Refrigeration and Cooling Equipment
  5. Heating Equipment
  6. Variable Flow Water Systems
  7. Duct Systems
  8. Economizers
  9. Makeup and Exhaust Systems
  10. Variable Air Volume Systems
- 8.
- 9.
- 10.

# There Was a Point In Time Where I Didn't Know Any of This

1972

- Set out to be an airplane mechanic and aircraft maintenance engineer



# There Was a Point In Time Where I Didn't Know Any of This

1976

- Reality intervenes



*Image Courtesy [www.kpluwonders.org/](http://www.kpluwonders.org/)*

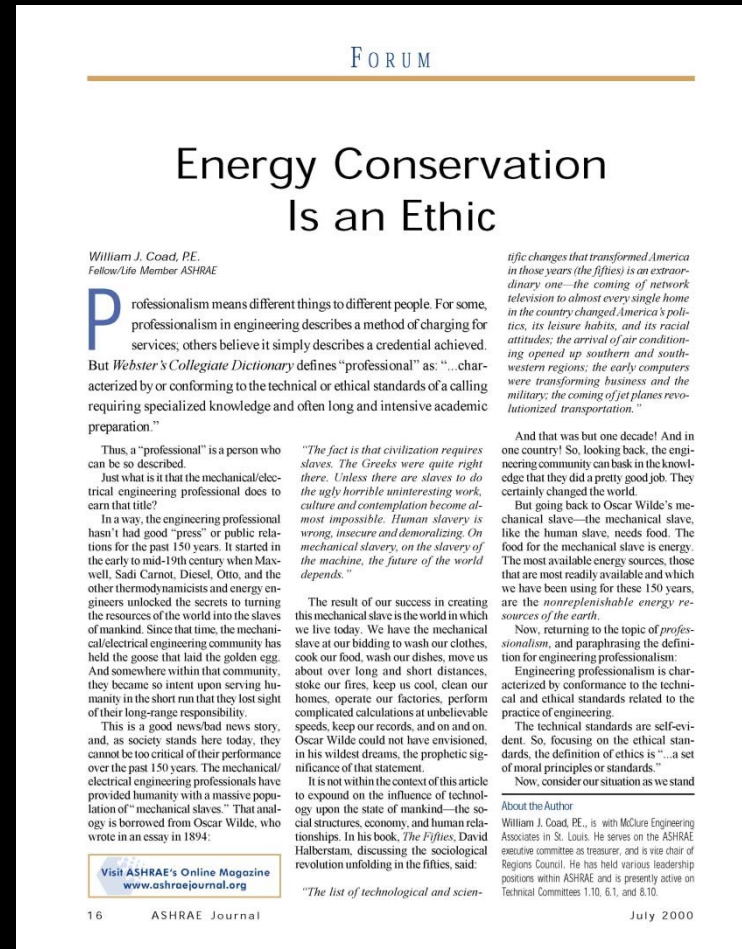
# There Was a Point In Time Where I Didn't Know Any of This

1976

- Bill Coad inspires me to think a different way...

... that is to practice our profession with an emphasis upon our responsibility to protect the long-range interests of the society we serve and, specifically, to incorporate the ethics of energy conservation and environmental preservation in everything we do.

ASHRAE Journal, vol. 42, no. 7, p. 16-21  
[www.ASHRAE.org](http://www.ASHRAE.org)





# There Was a Point In Time Where I Didn't Know Any of This

1976 Through Present

- I change career paths and am blessed with great mentors



NEVER NEVER LOOSE SIGHT  
OF THE FACT THAT YOU CAN BE ANYTHING  
YOU WANNA BE... YOU COULD BE SOMETHING  
AS SIMPLE AS A NOSE, MUSTACHE OR A SMILE.  
OR, FOR THAT MATTER, AS COMPLEX AS A DOG, TREE  
OR BARBED WIRE FENCE...  
HECK, YOU COULD BE  
THE PRESIDENT!



AN INSPIRATIONAL  
APPROACH TO CARTOONING

RJ BALLARD

<http://www.rjballard.com/thefront.htm>

# What Is Commissioning?



Main Entry: commission \kə-'mi-shən\

Function: transitive verb

Inflected Form(s): -mis·sioned; com·mis·sion·ing /-'mi-sh(&-)ni[ng]/

1 : to furnish with a commission: as a : to confer a formal commission on <was commissioned lieutenant> b : to appoint or assign to a task or function <was commissioned to do the biography>

2 : to order to be made <commissioned a portrait>





3 : to put (a ship) in commission

*An analogy to a ship's sea trials  
or "shake-down" cruise*

*Image courtesy [www.public-domain-image.com](http://www.public-domain-image.com)*

# Commissioning;

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the contract documents, the design intent and the Owner's operational needs

- Begins in predesign
- Documents the design intent
- Continues through construction, acceptance, the warranty period, and through the building's life cycle
- Includes functional testing
- Includes training
- Documents performance

# Commissioning; Not a One Time Event

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the contract documents, the design intent and the Owner's operational needs

- *Begins in predesign*
- Documents the design intent
- *Continues through construction, acceptance, the warranty period, and through the building's life cycle*
- Includes functional testing
- Includes training
- Documents performance

# Commissioning; Bottom line

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the contract documents, the design intent and the Owner's operational needs

- *Begins in predesign*
- Documents the design intent
- *Continues through construction, acceptance, the warranty period, and through the building's life cycle*
- Includes functional testing
- Includes training
- Documents performance

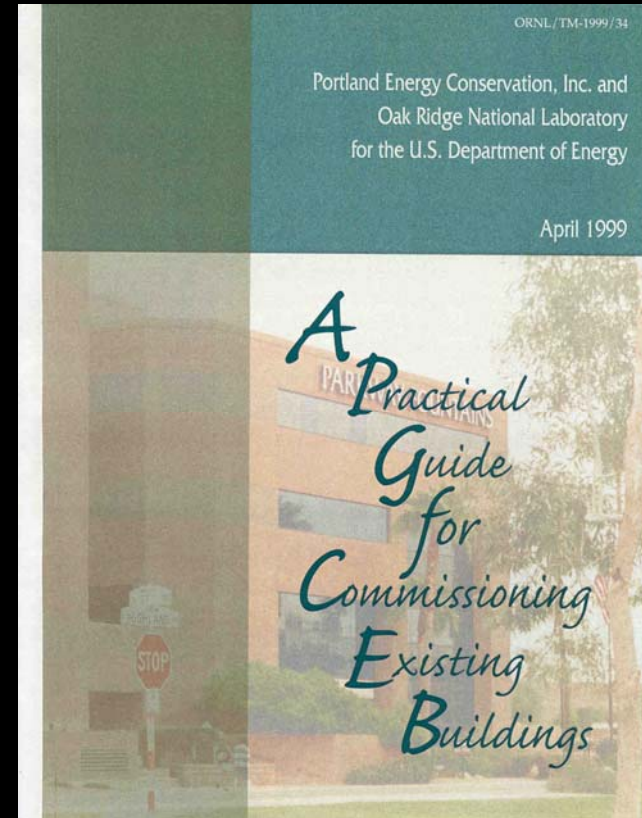
*Commissioning is about performance and integration*

# My Content will be Technical Content

Not so much about the Cx/RCx process ...

... More about what to do when you're doing the process!

Guidelines can be found at  
[www.PECI.org](http://www.PECI.org) and [www.CACx.org](http://www.CACx.org)





# What Is Retrocommissioning

In general terms, it's the same thing as:

- RCx
- Existing Building Commissioning
- EBCx
- Recommissioning
- Building tune-up

# What is On-going Commissioning?

Continuous Commissioning™

*A Trademarked Process Developed by Texas A&M*

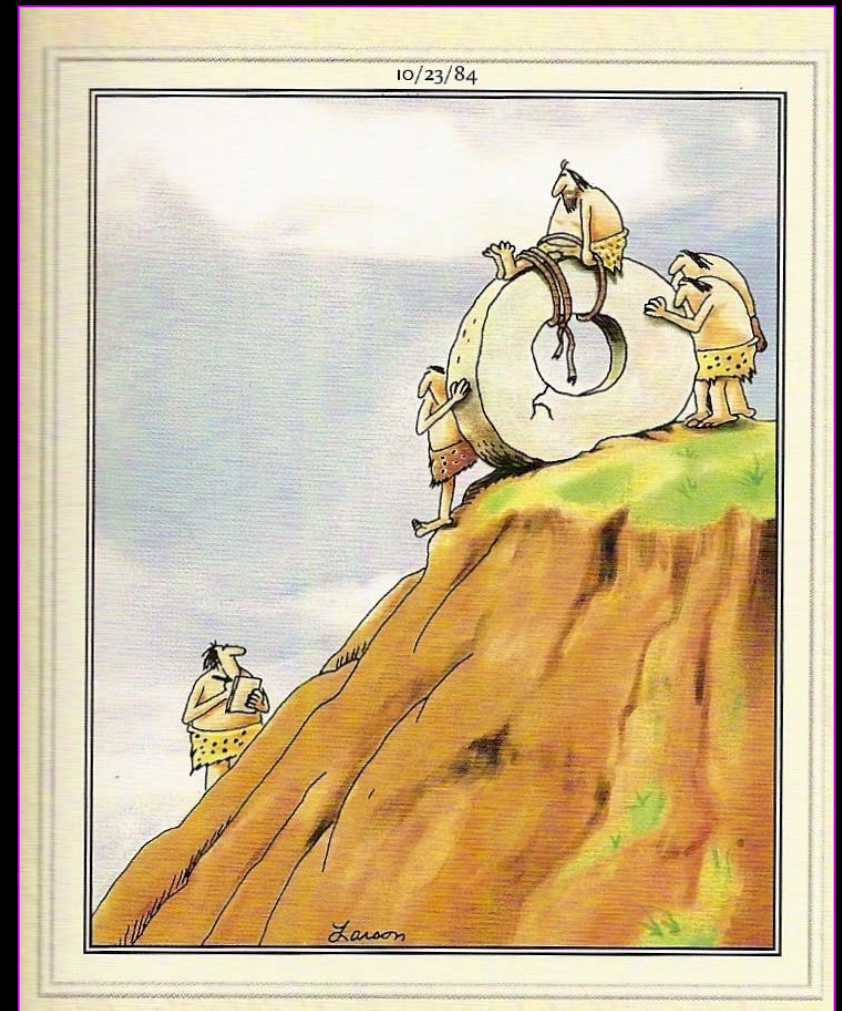
Operating the Building Properly

*What folks called it when I started doing this stuff (1976)*

# No Matter What “Flavor”

... Cx is a team effort!

The building systems  
aren't the only thing that  
will be interactive and  
require integration from  
the Cx provider



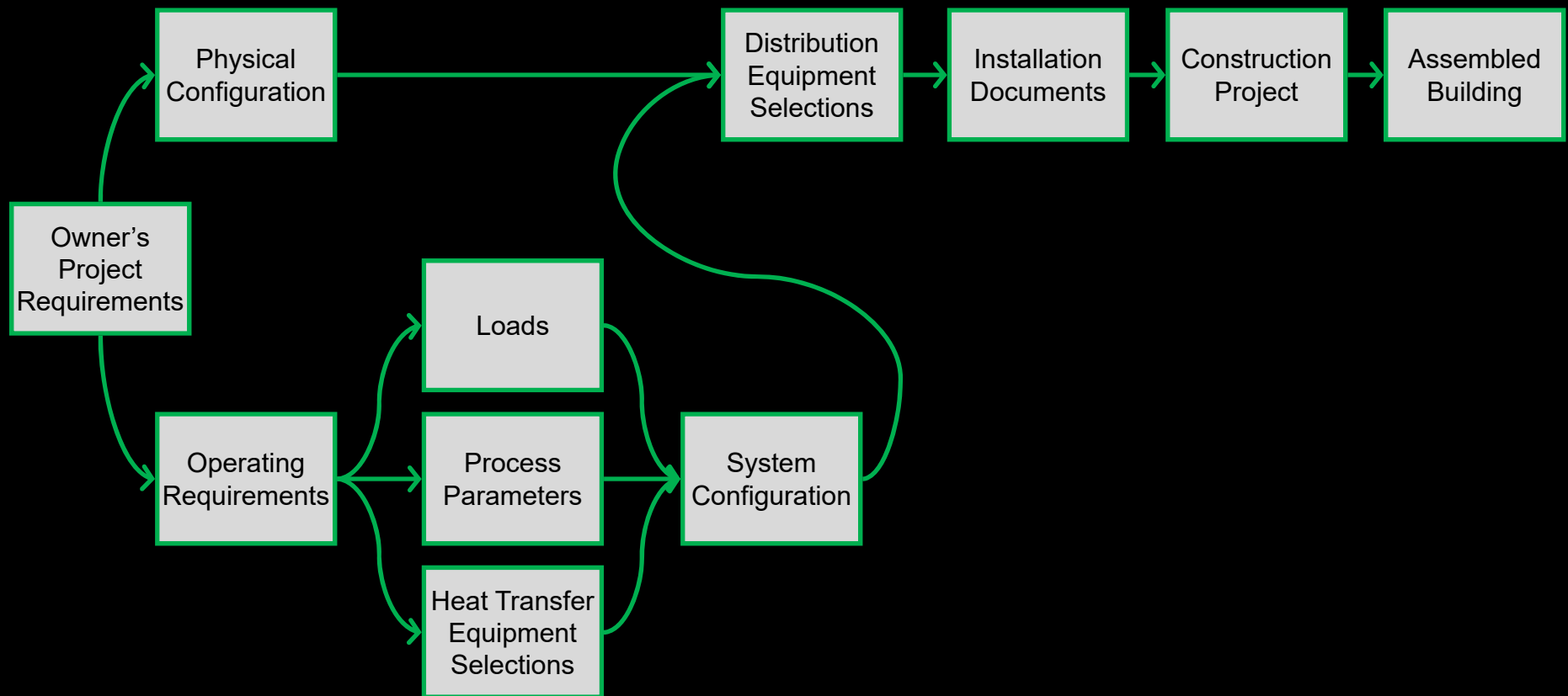
Prehistoric Commissioning Team

# Empower Your Team



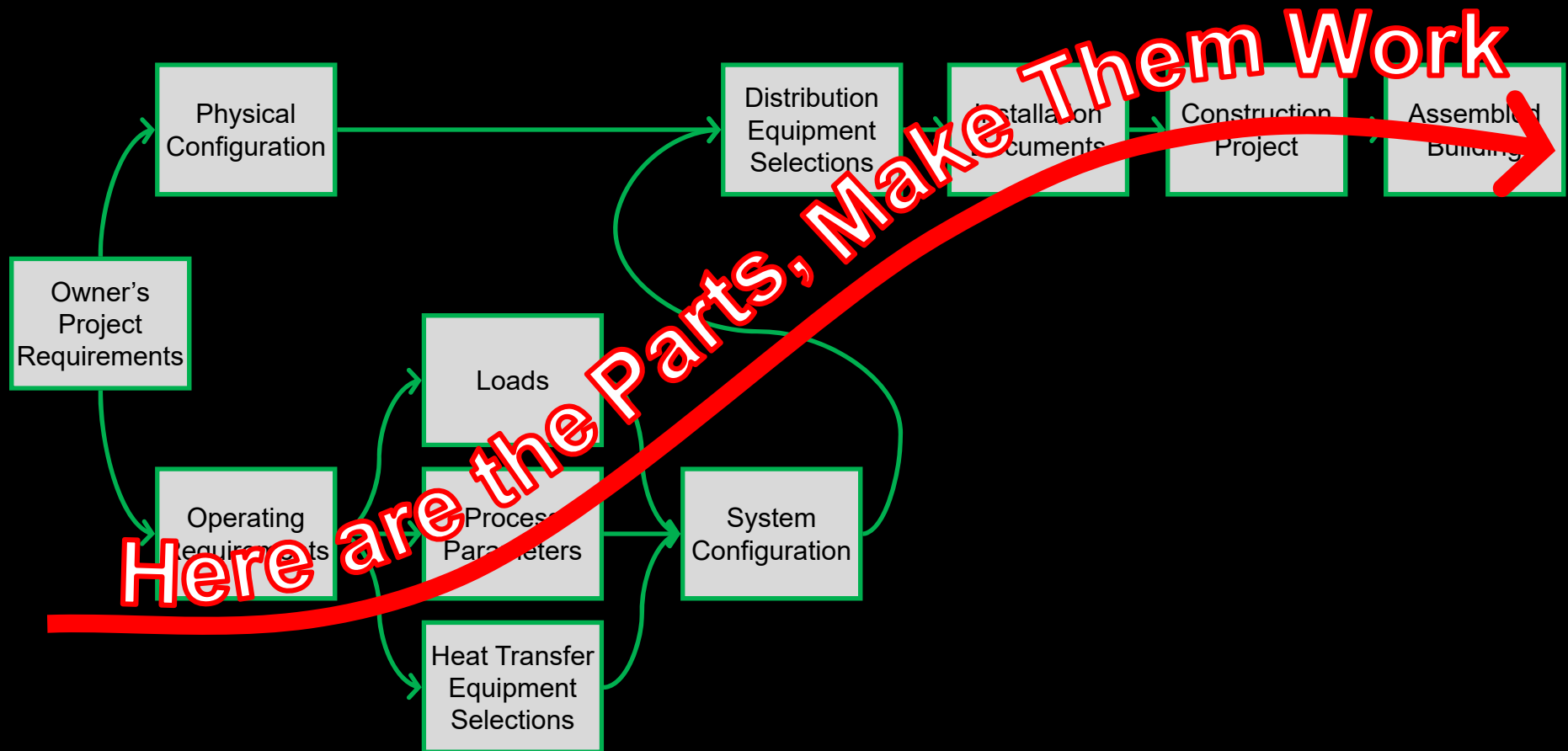
INTRODUCTION

# New Construction vs. Existing Building Cx

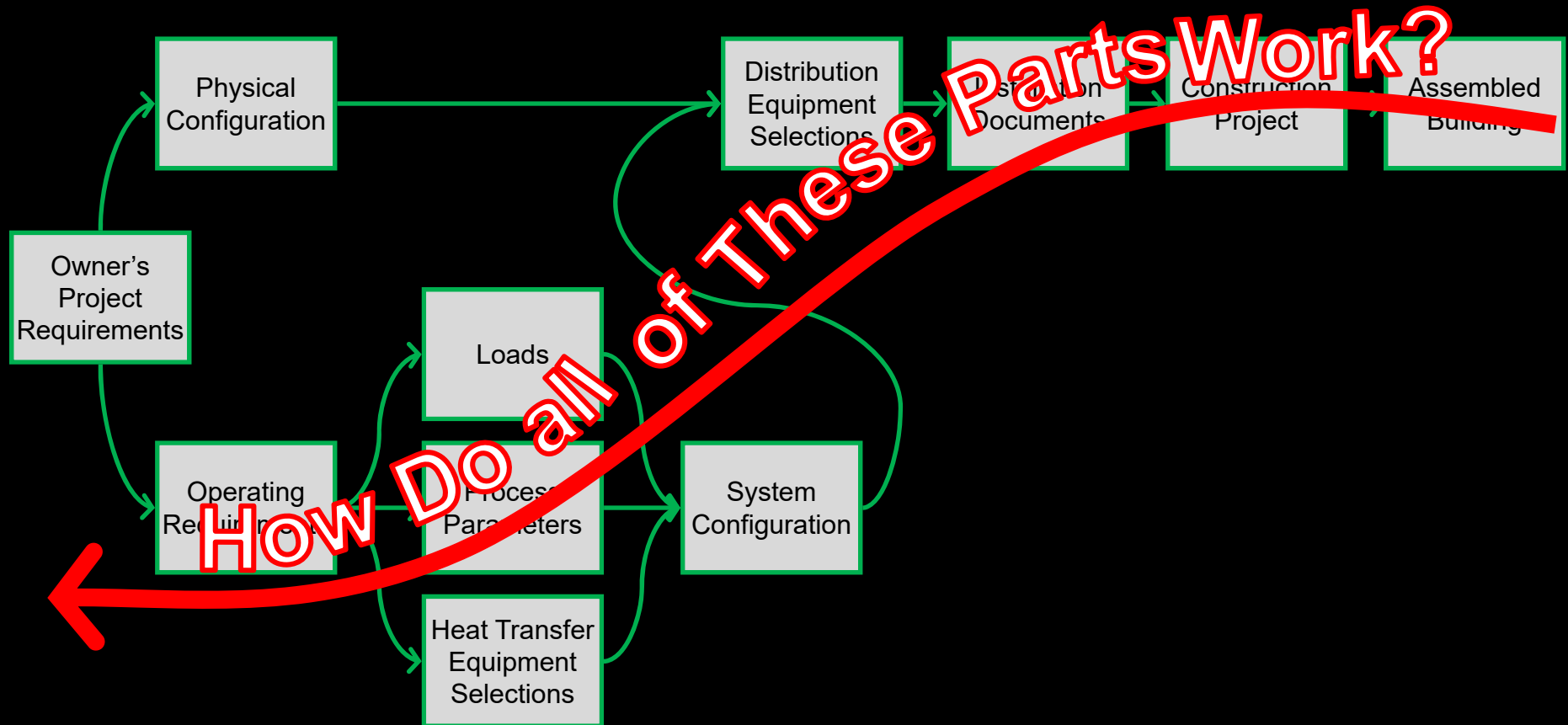




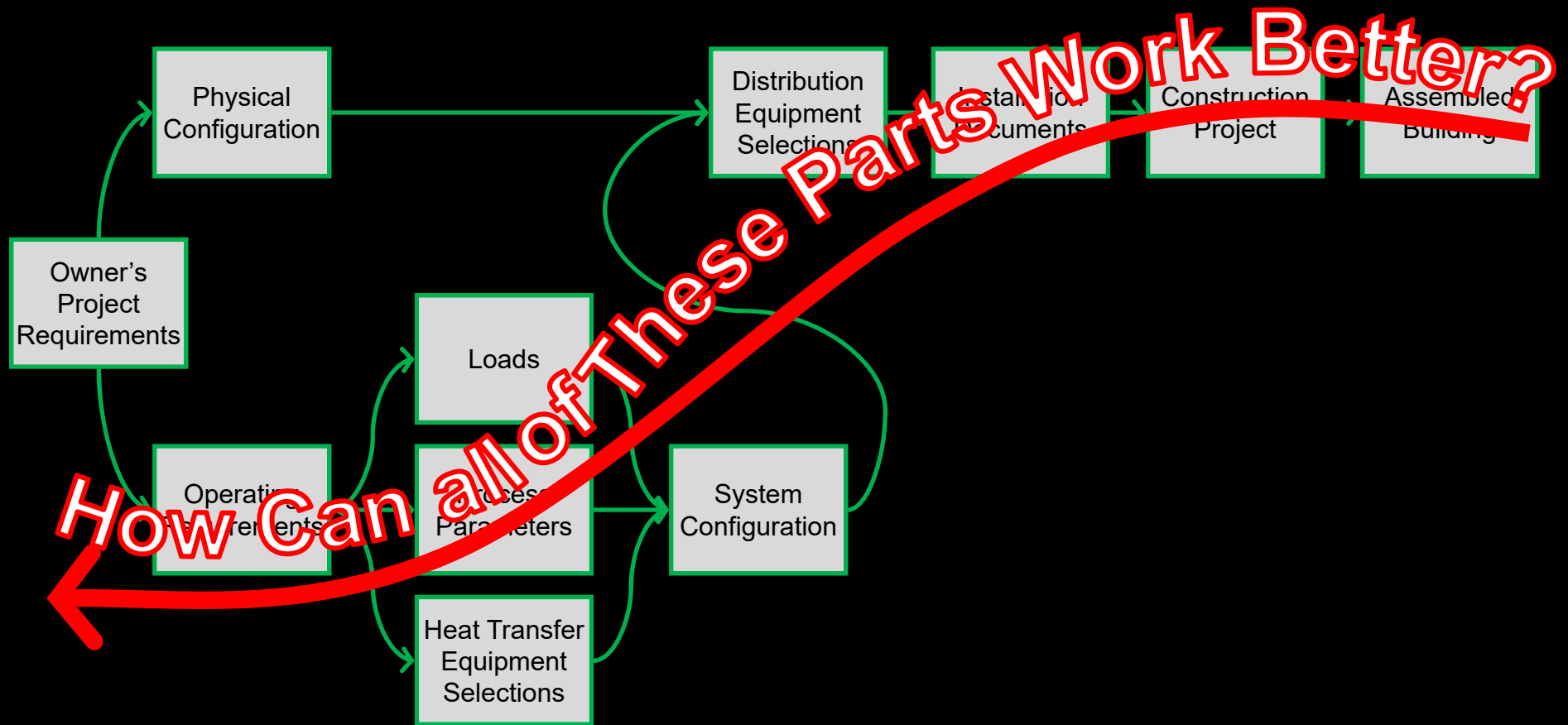
# New Construction vs. Existing Building Cx



# New Construction vs. Existing Building Cx



# New Construction vs. Existing Building Cx

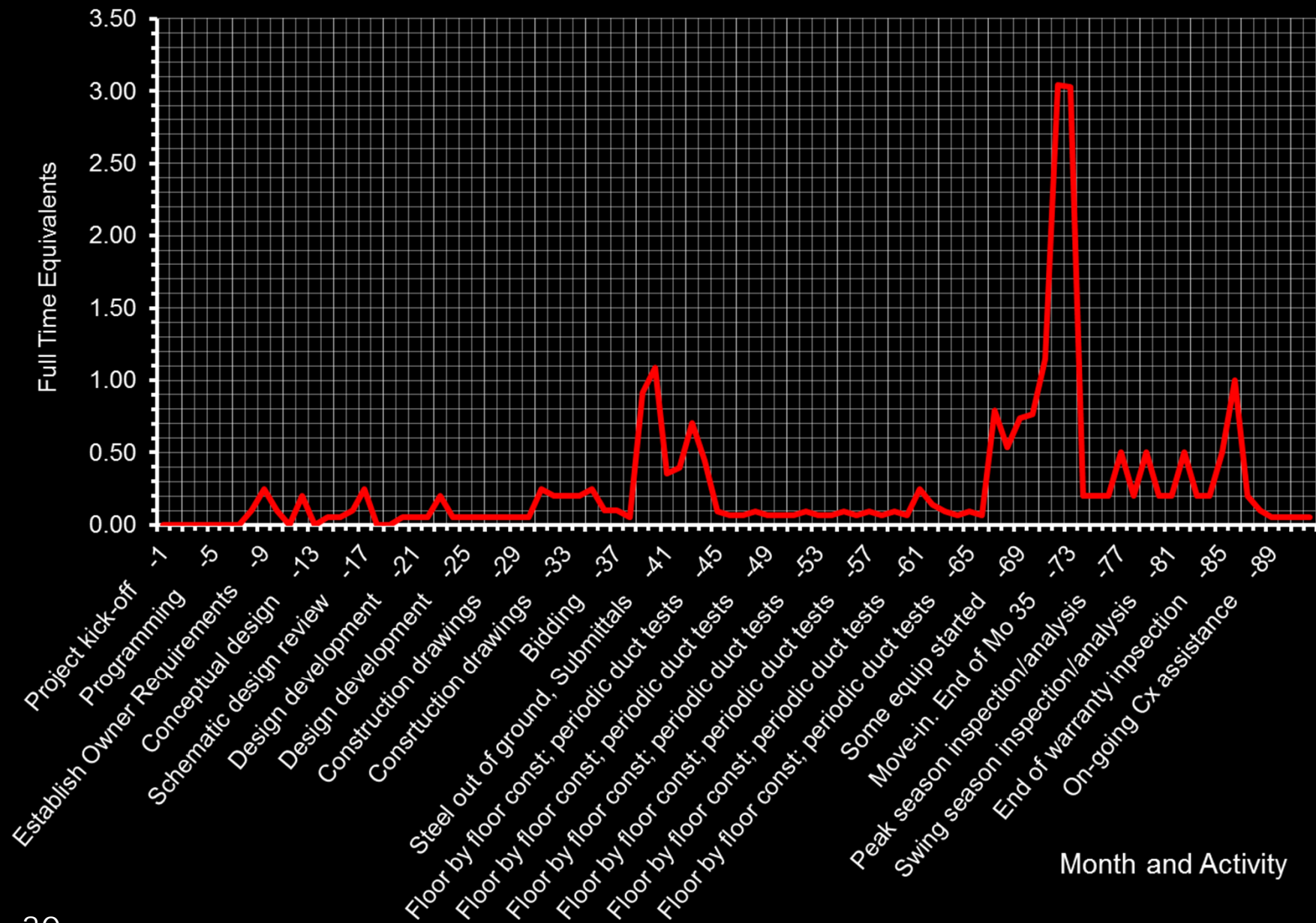




# New Construction vs. Existing Building Cx as it Relates to the Project Timeline

## Typical New Construction Commissioning Activity

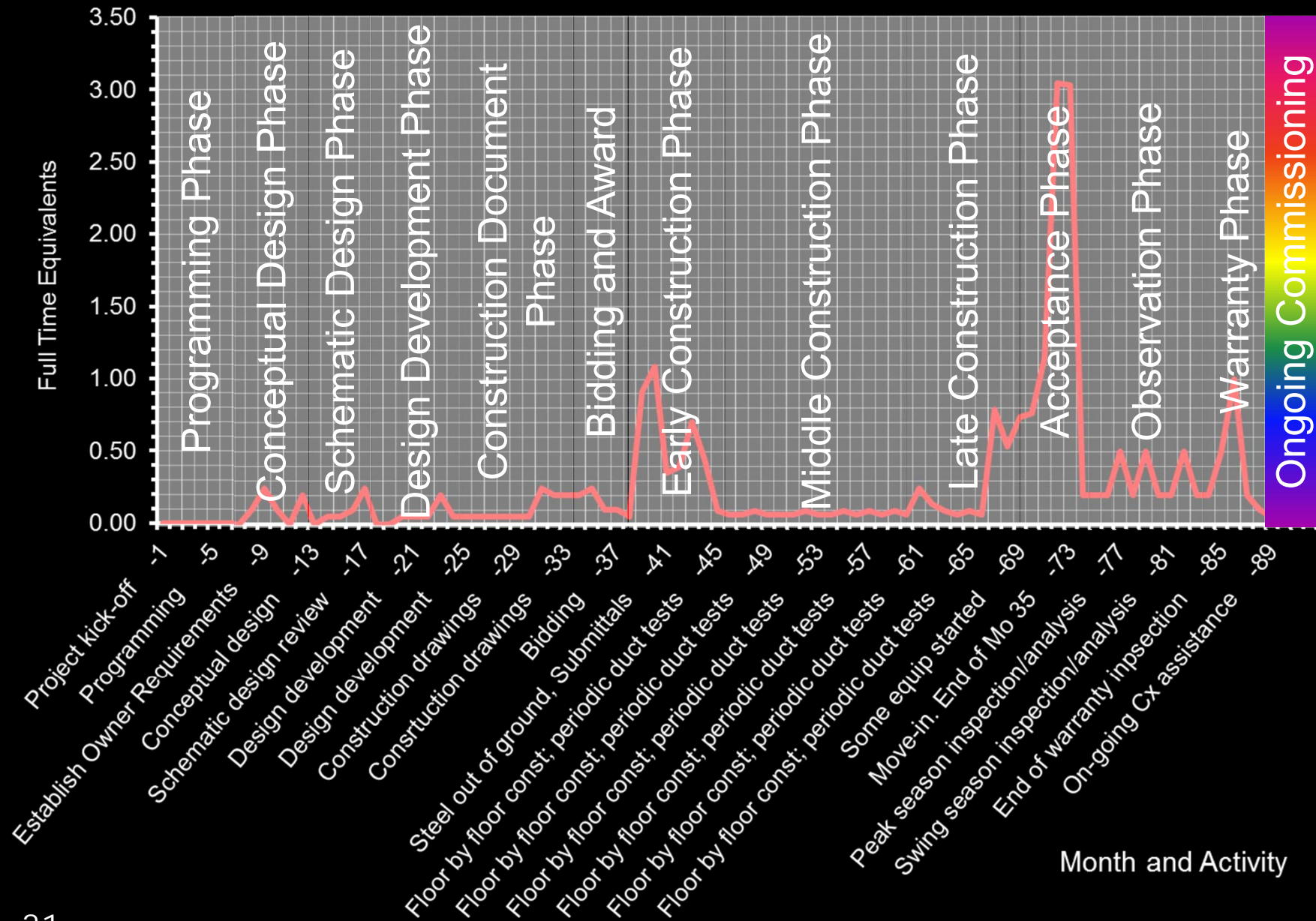
600,000 sq.ft. High Rise Basis



Month and Activity

# Typical New Construction Commissioning Activity

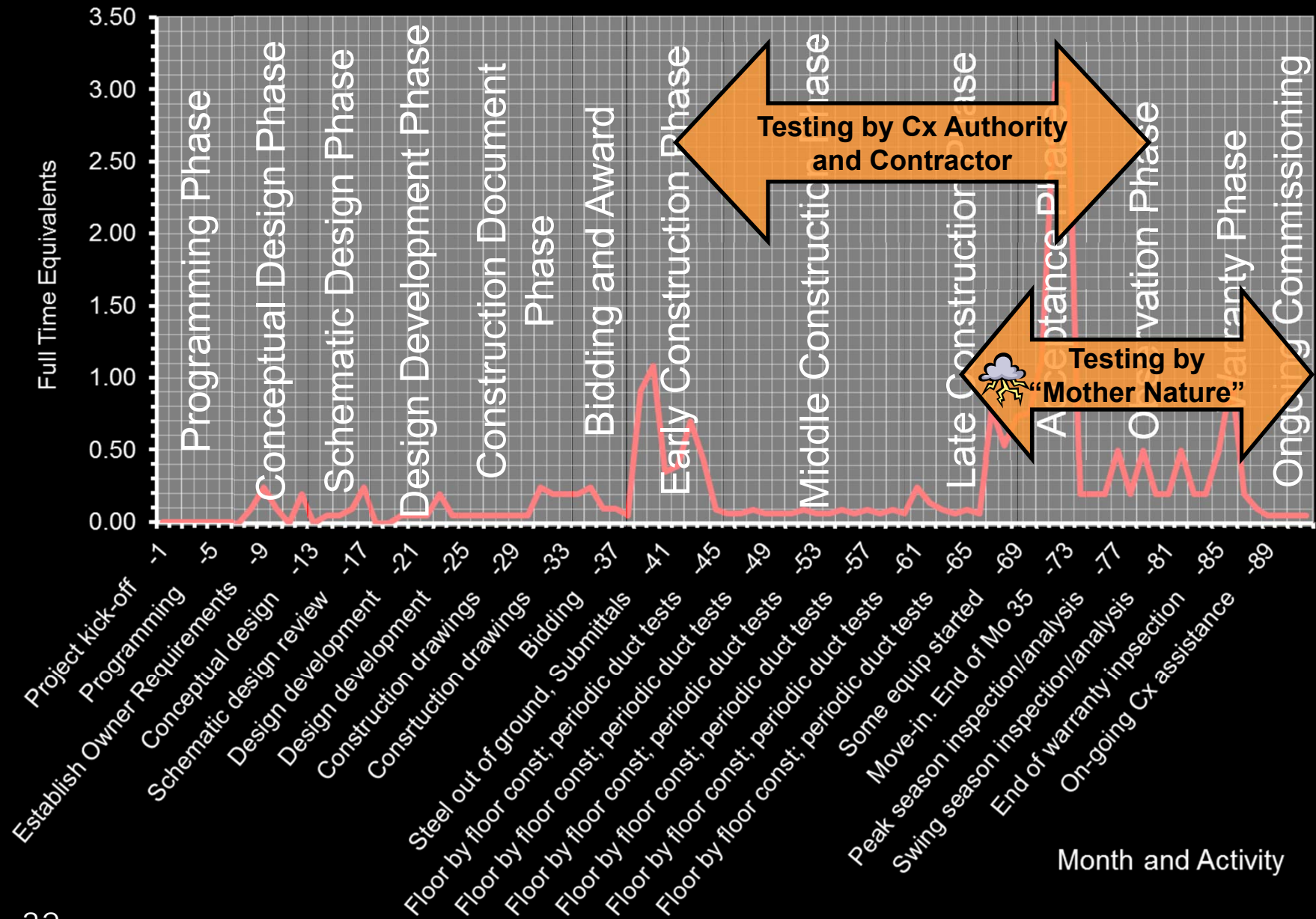
600,000 sq.ft. High Rise Basis



Month and Activity

# Typical New Construction Commissioning Activity

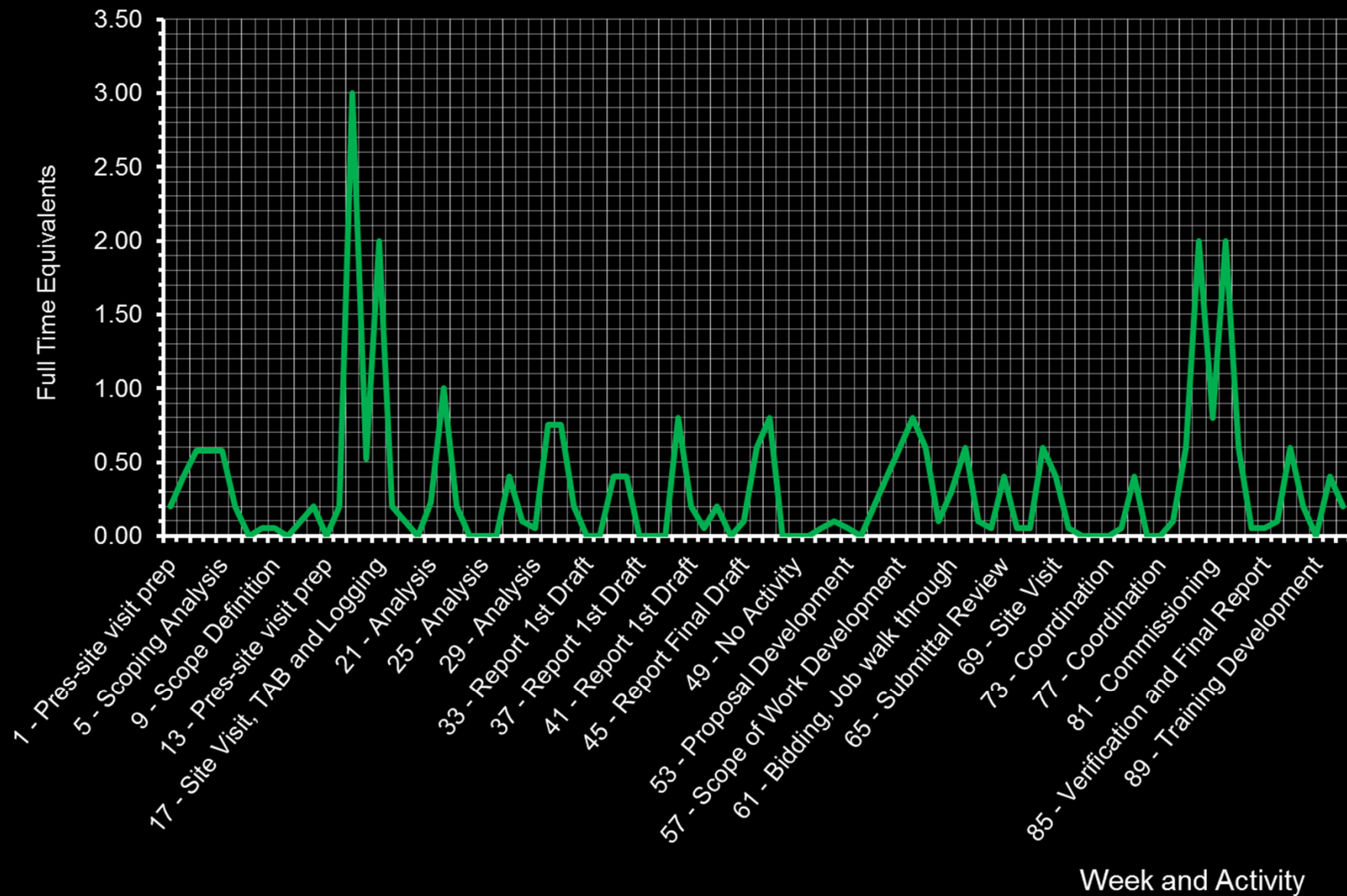
600,000 sq.ft. High Rise Basis





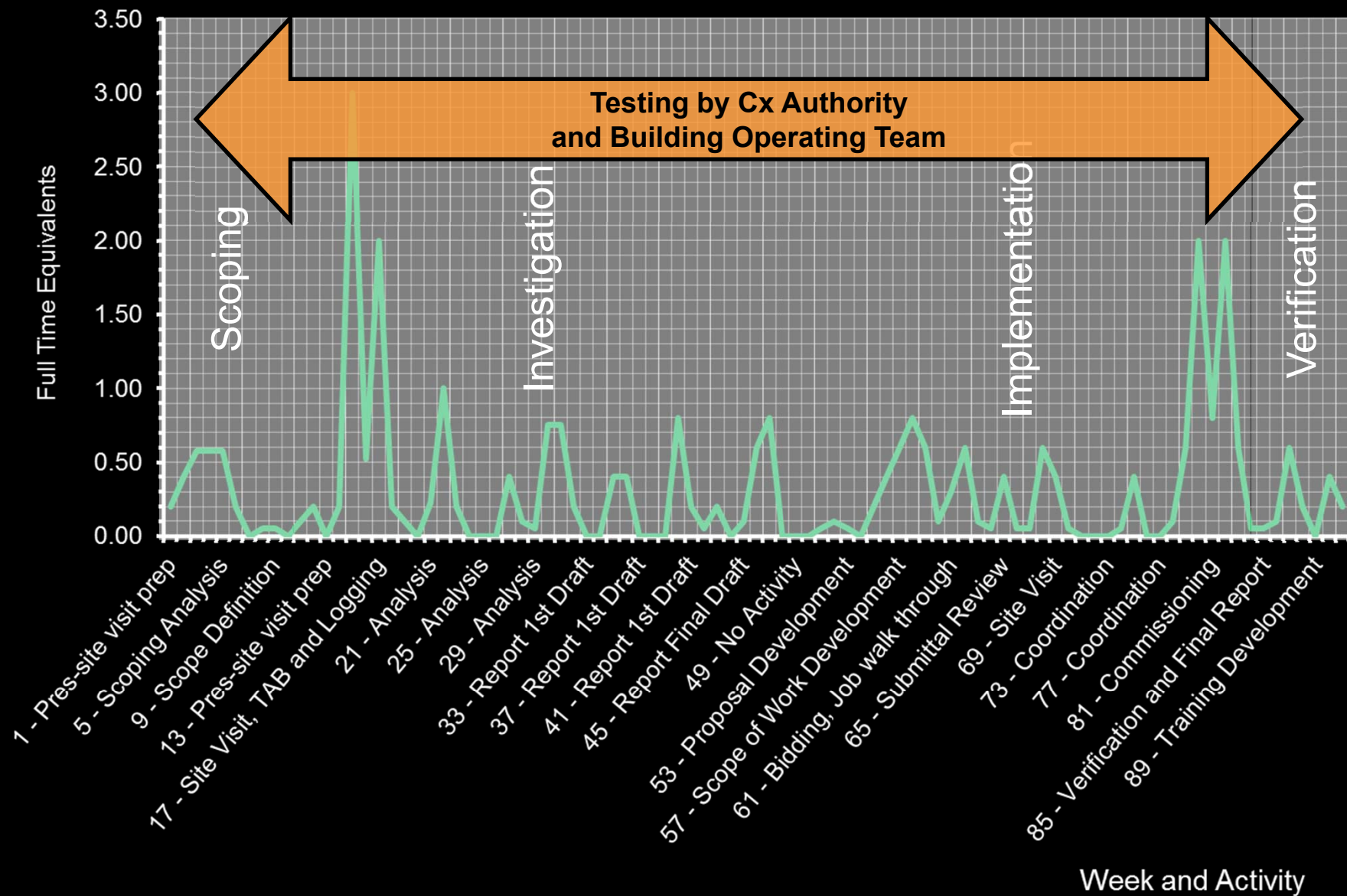
# Typical Existing Building Construction Commissioning Activity

750,000 sq.ft. Hospital Basis



# Typical Existing Building Construction Commissioning Activity

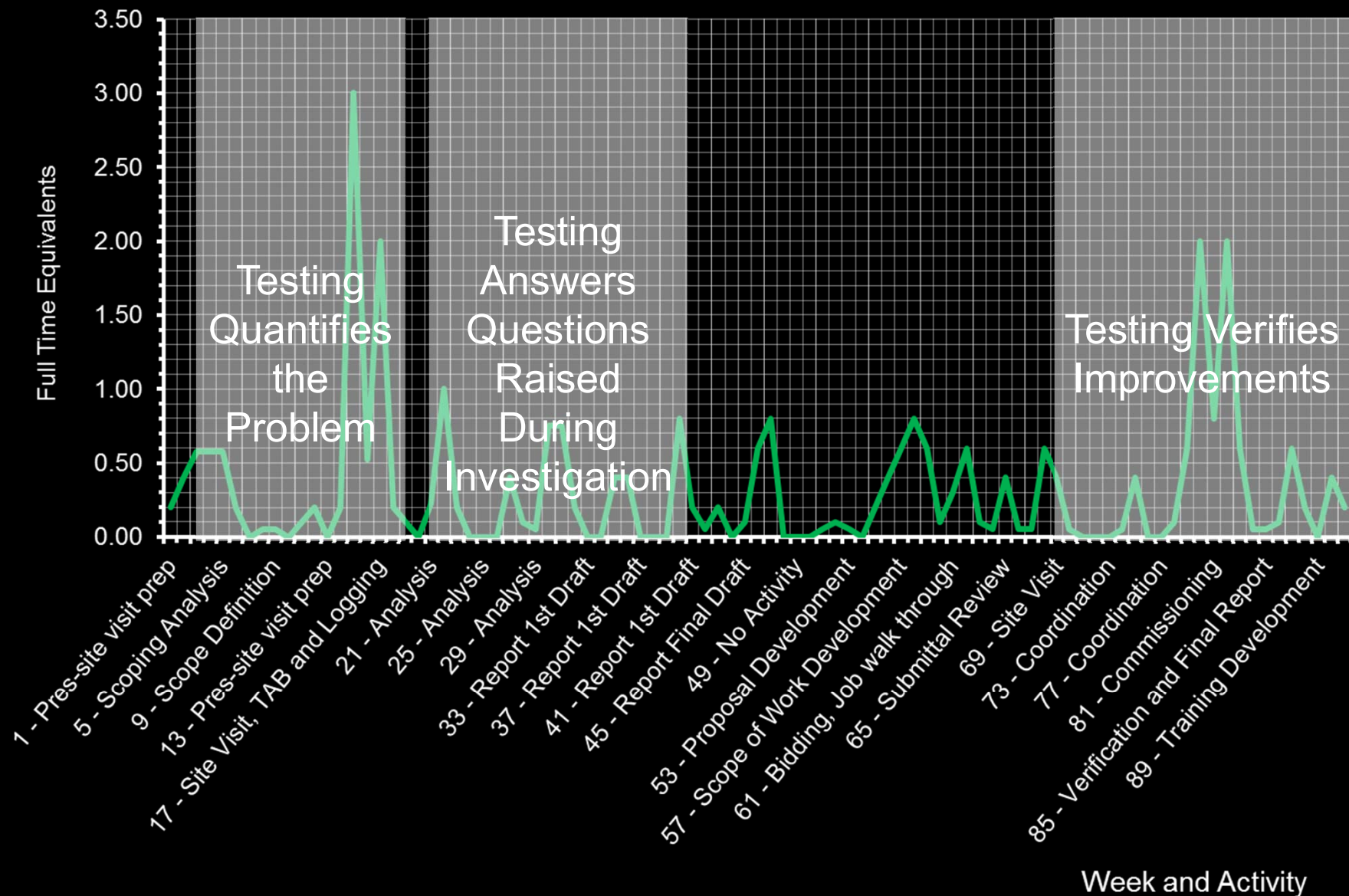
750,000 sq.ft. Hospital Basis





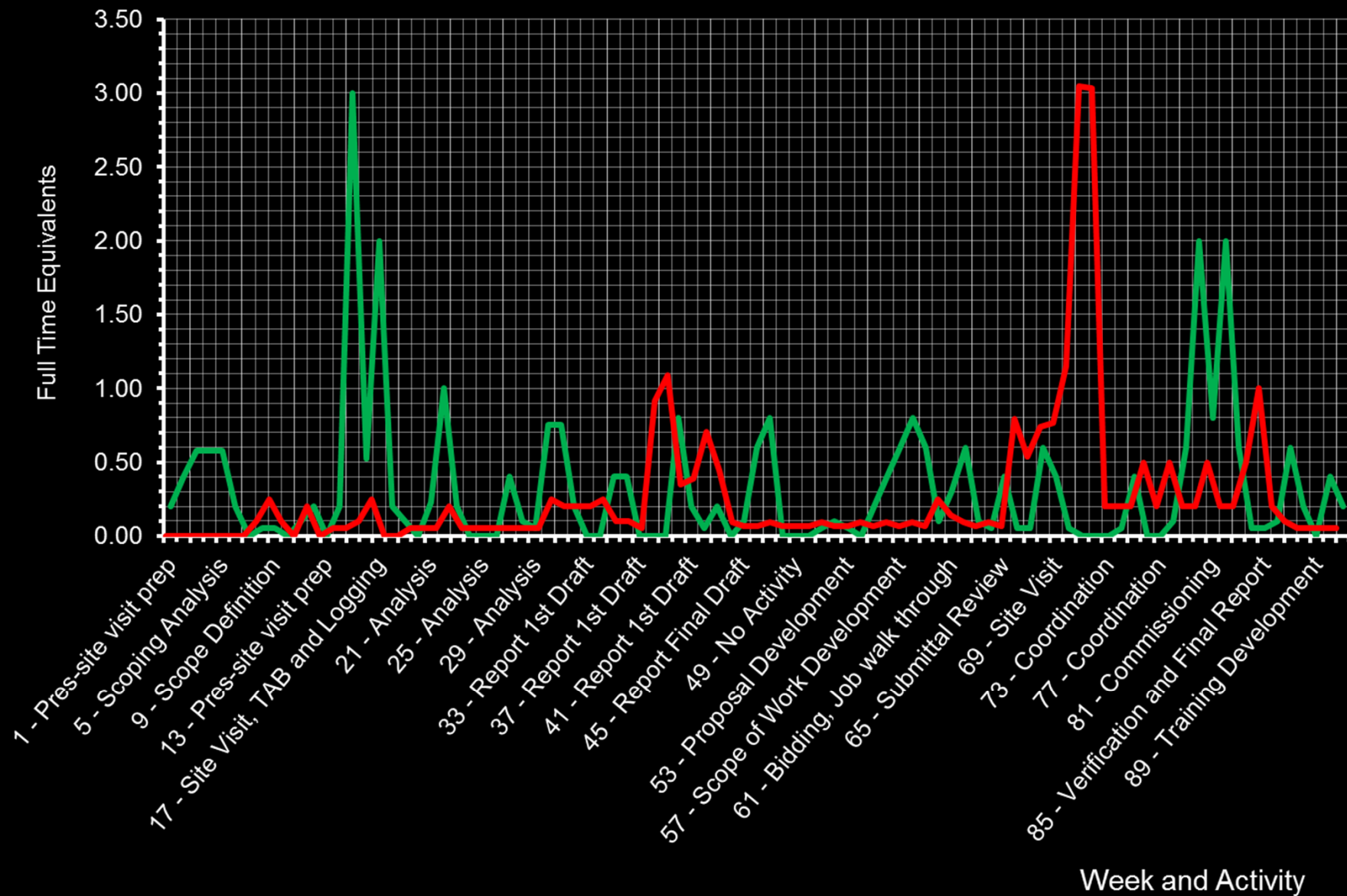
# Typical Existing Building Construction Commissioning Activity

750,000 sq.ft. Hospital Basis



# Typical Existing Building Construction Commissioning Activity

750,000 sq.ft. Hospital Basis



# New Construction vs. Existing Building Cx Bottom Lines

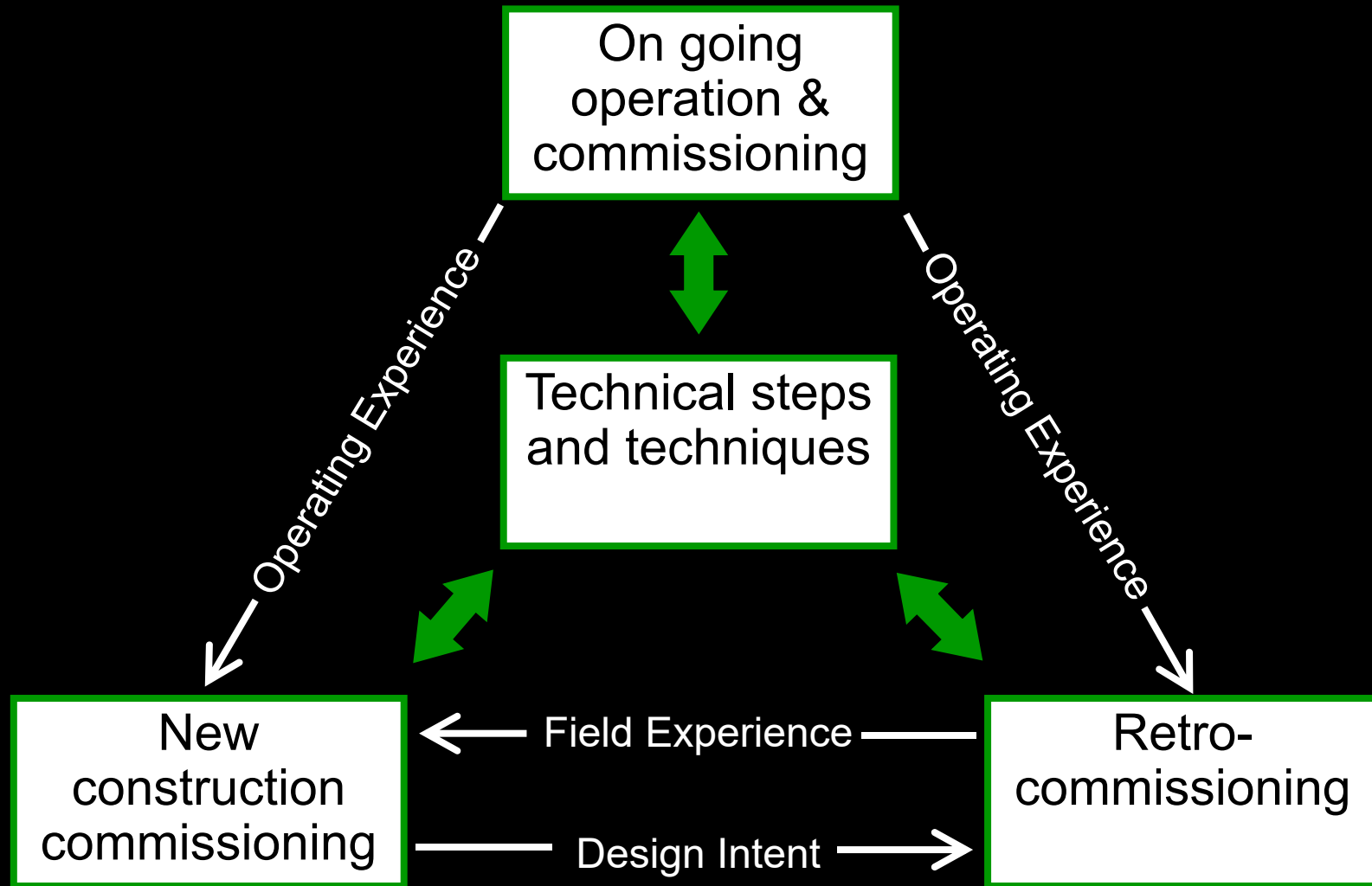
## New Construction

- Trying to prove design intent
- Demonstrate all elements of the system meet requirements
- Verification and quality assurance process

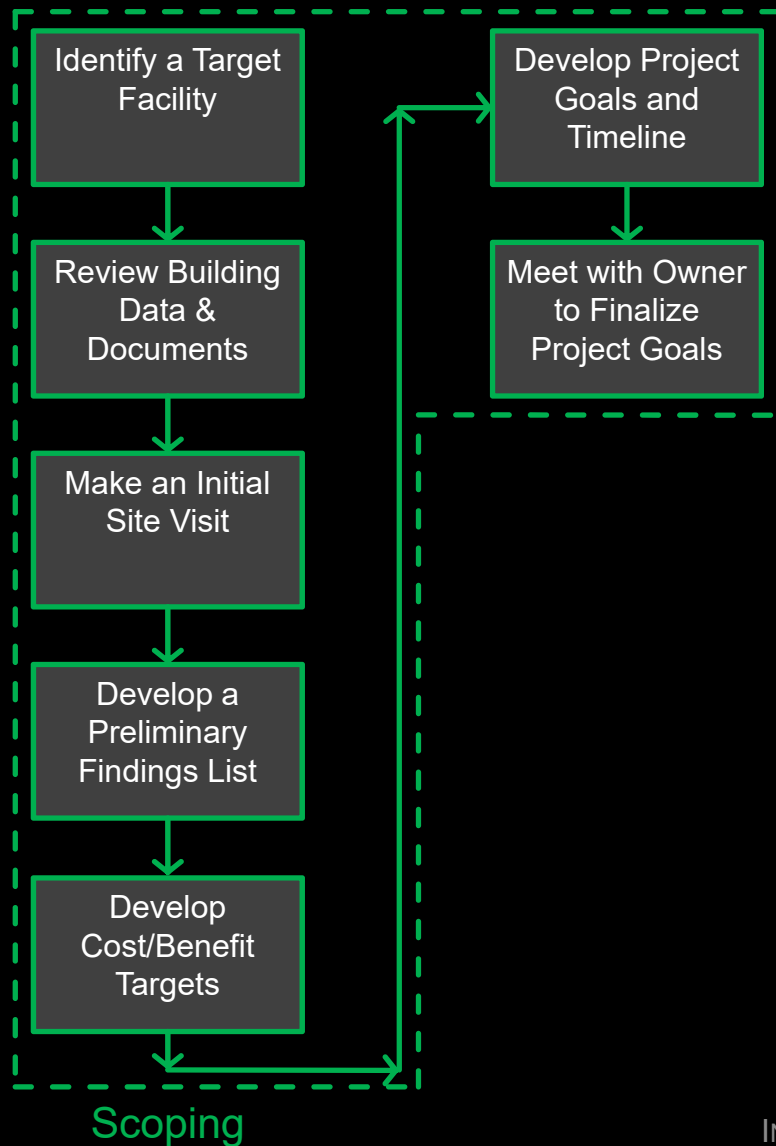
## EBCx

- Trying to understand design intent
- Focused on certain elements of the system
- Diagnostic and troubleshooting process

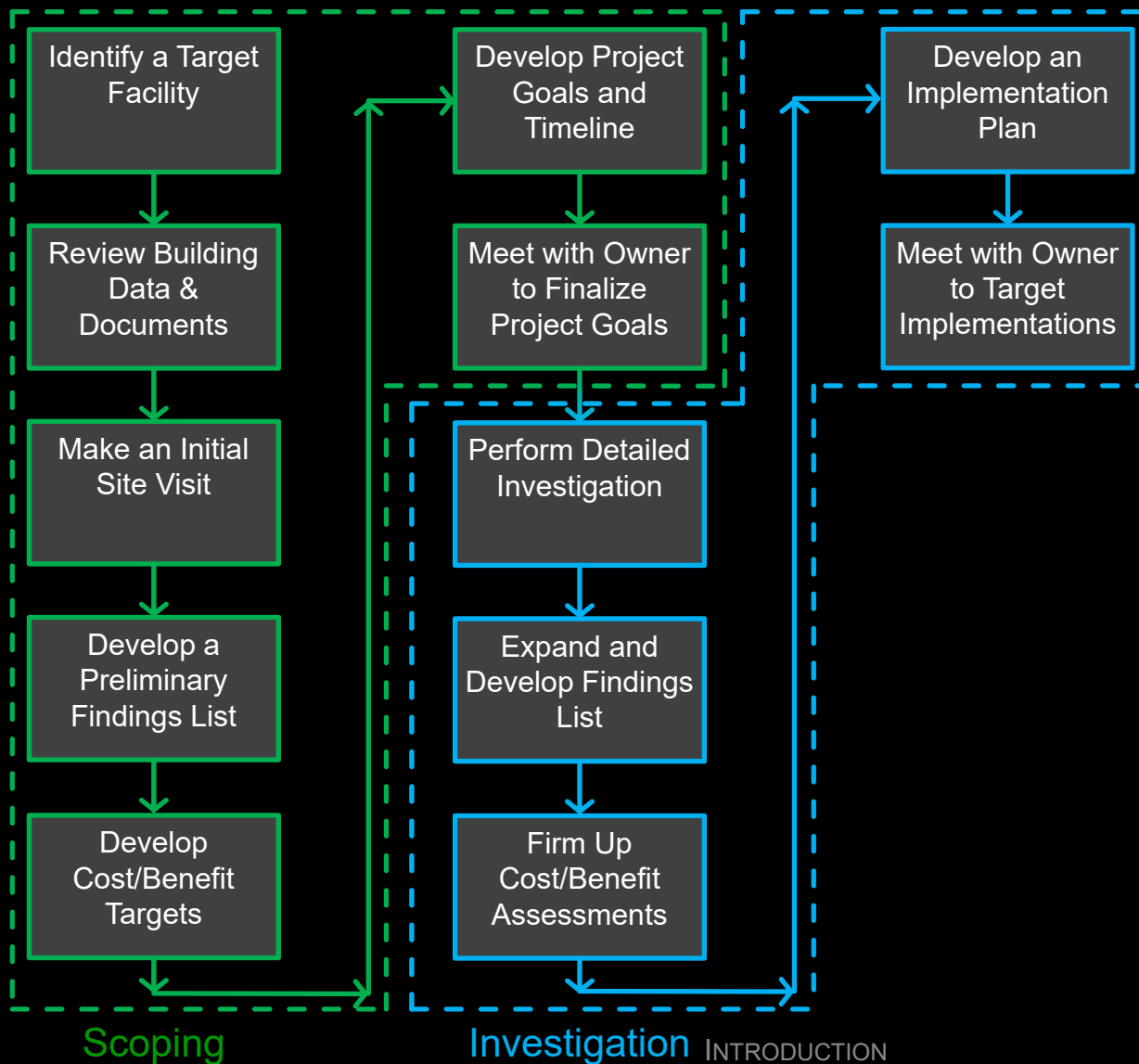
# New Construction vs. Existing Building Cx Bottom Lines



# A Typical Existing Building Commissioning Process

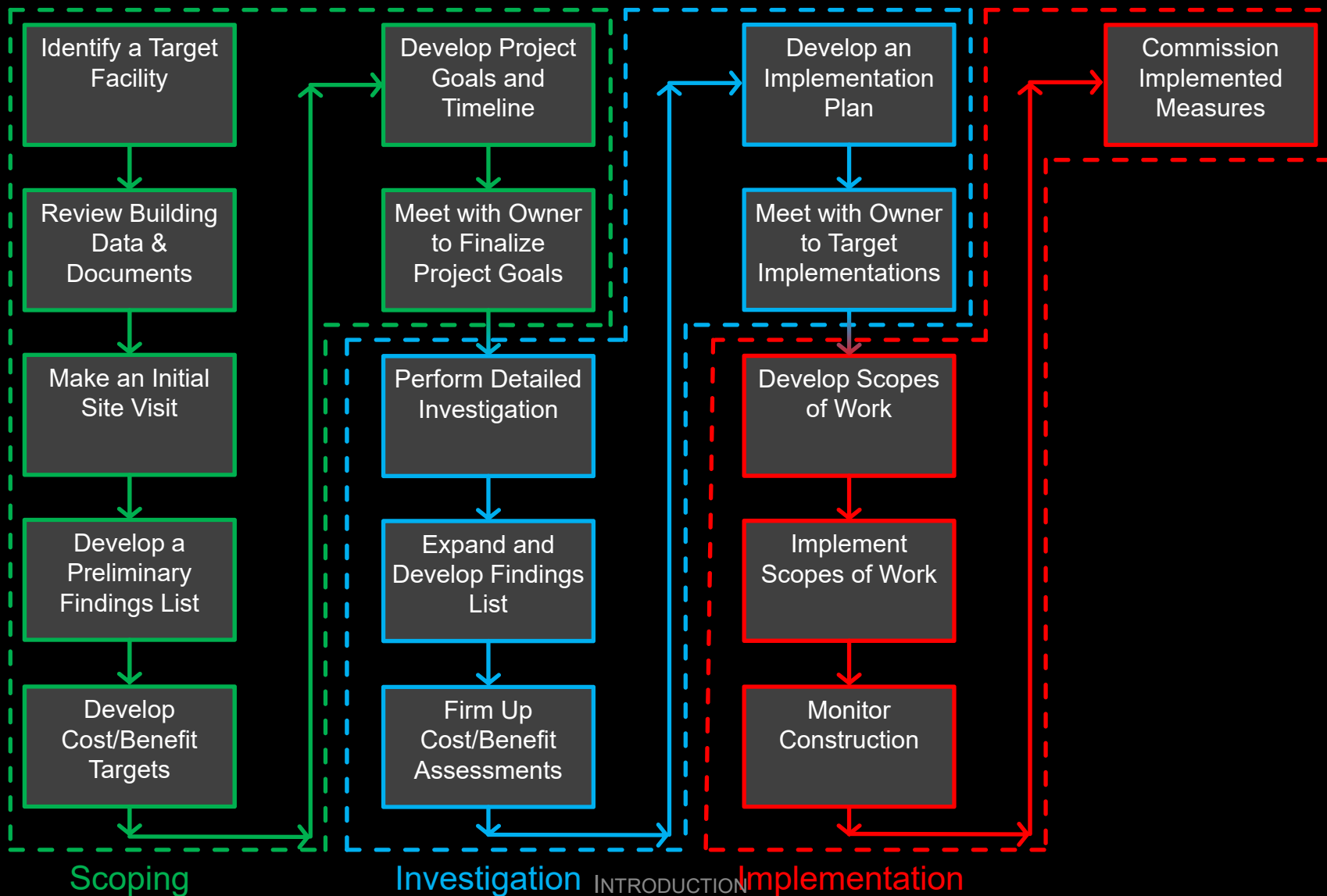


# A Typical Existing Building Commissioning Process

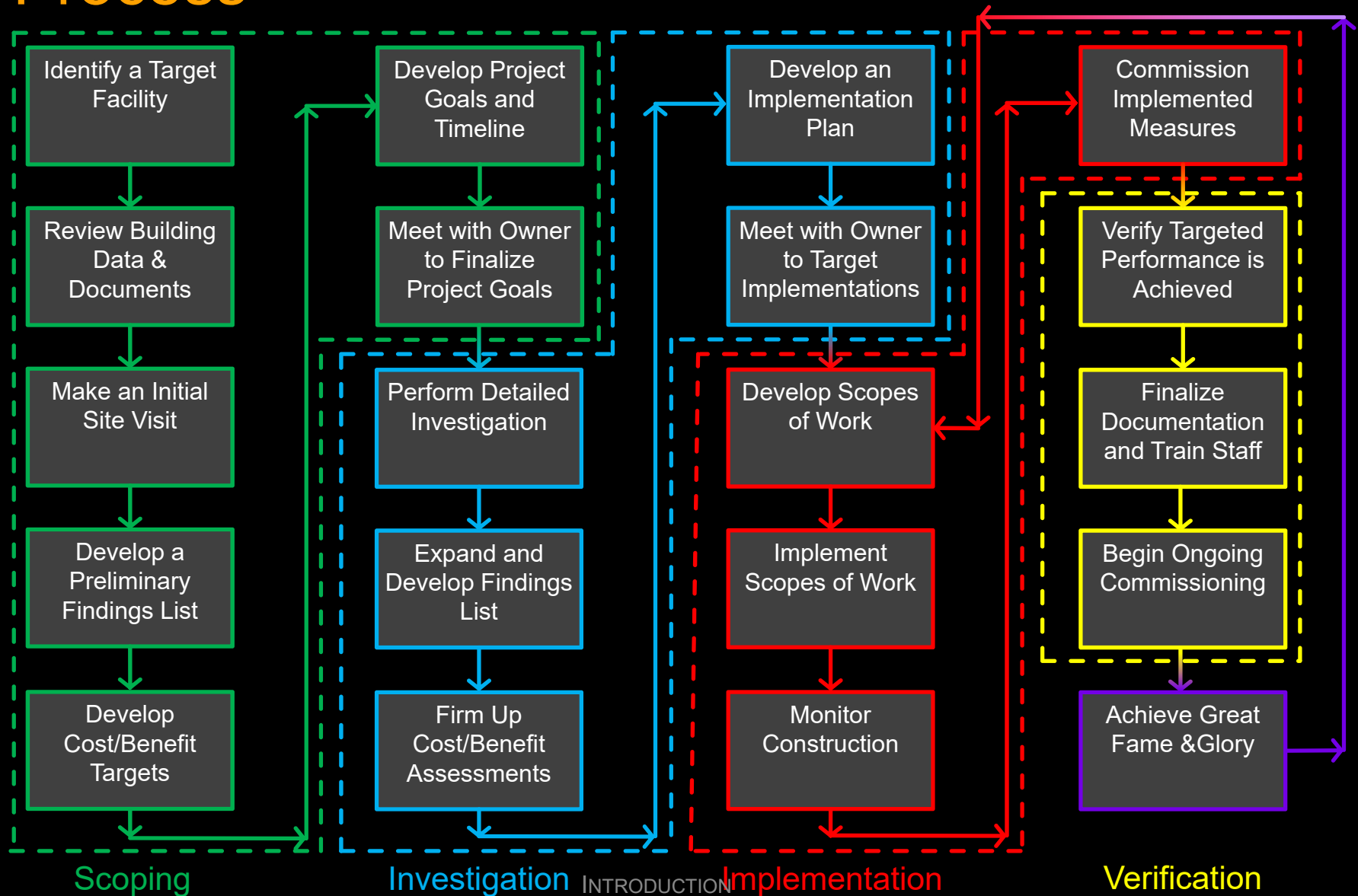




# A Typical Existing Building Commissioning Process



# A Typical Existing Building Commissioning Process



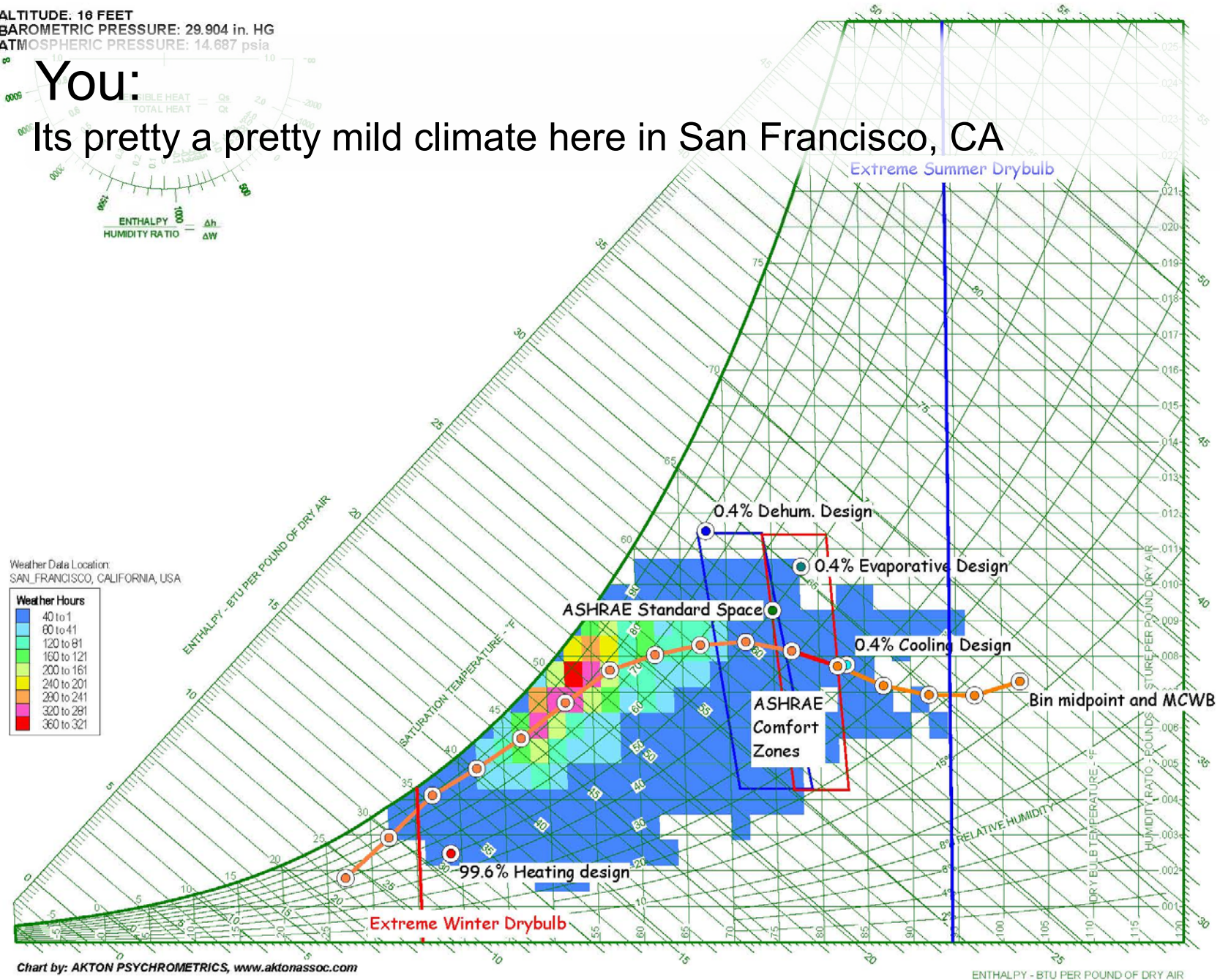
# The Buildings are Talking To Us

*In the bigger picture, retrocommissioning is about having a dialog with the building.*

ALTITUDE: 16 FEET  
BAROMETRIC PRESSURE: 29.904 in. HG  
ATMOSPHERIC PRESSURE: 14.687 psia

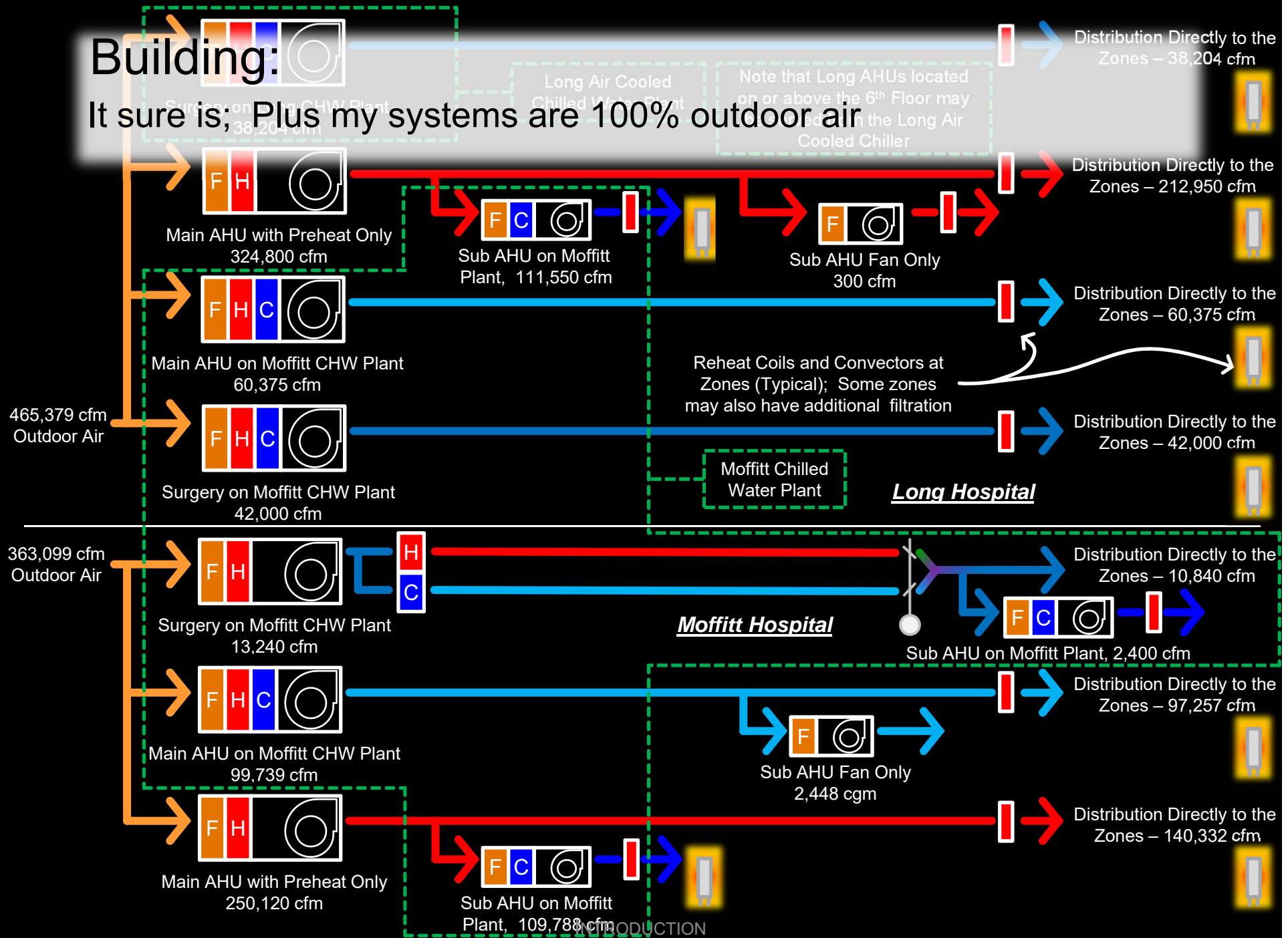
You:

Its pretty a pretty mild climate here in San Francisco, CA



# Building:

It sure is; Plus my systems are 100% outdoor air





You:

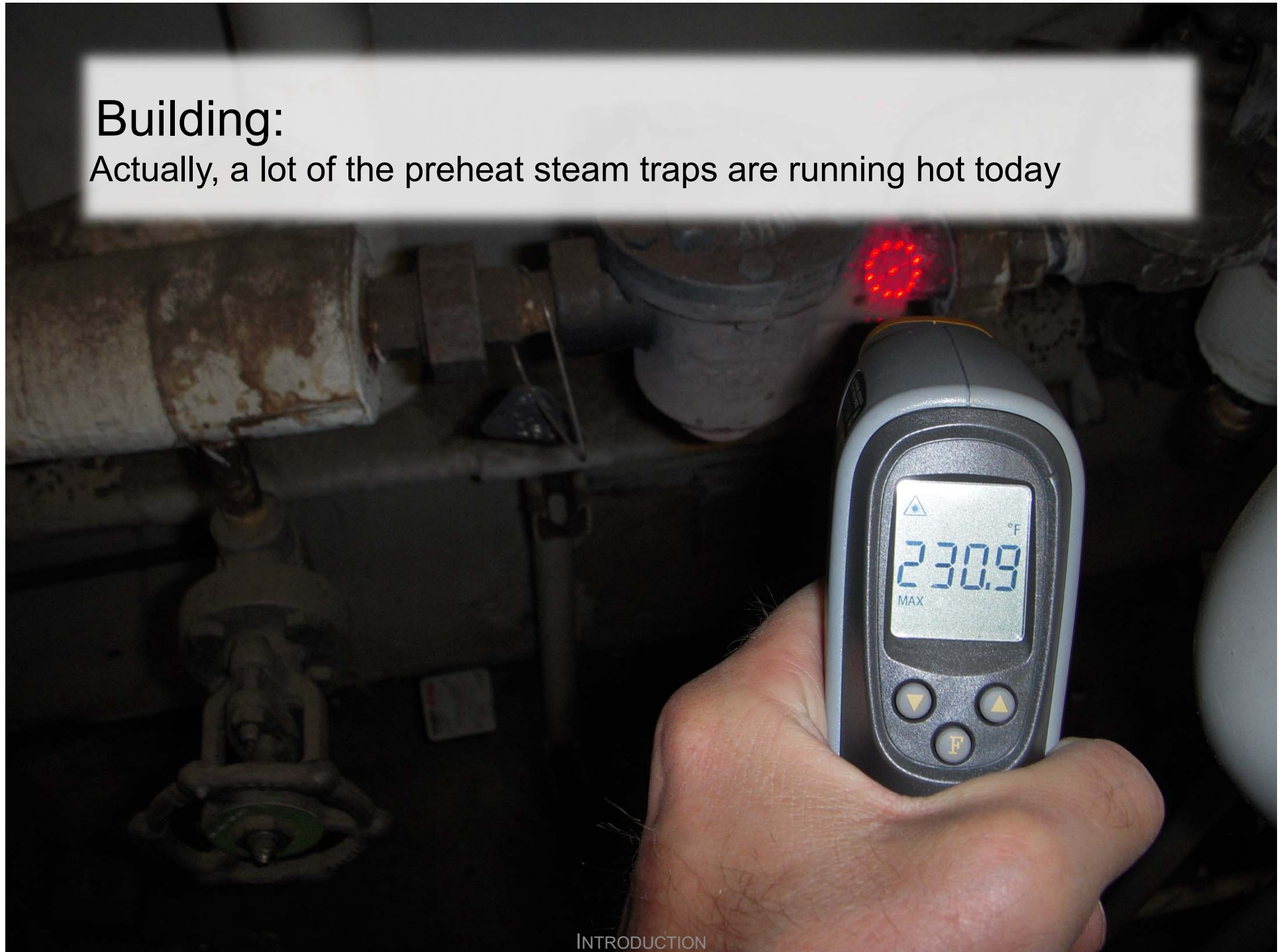
I doubt if your preheat coils will be doing much since its over 55°F outside





**Building:**

Actually, a lot of the preheat steam traps are running hot today



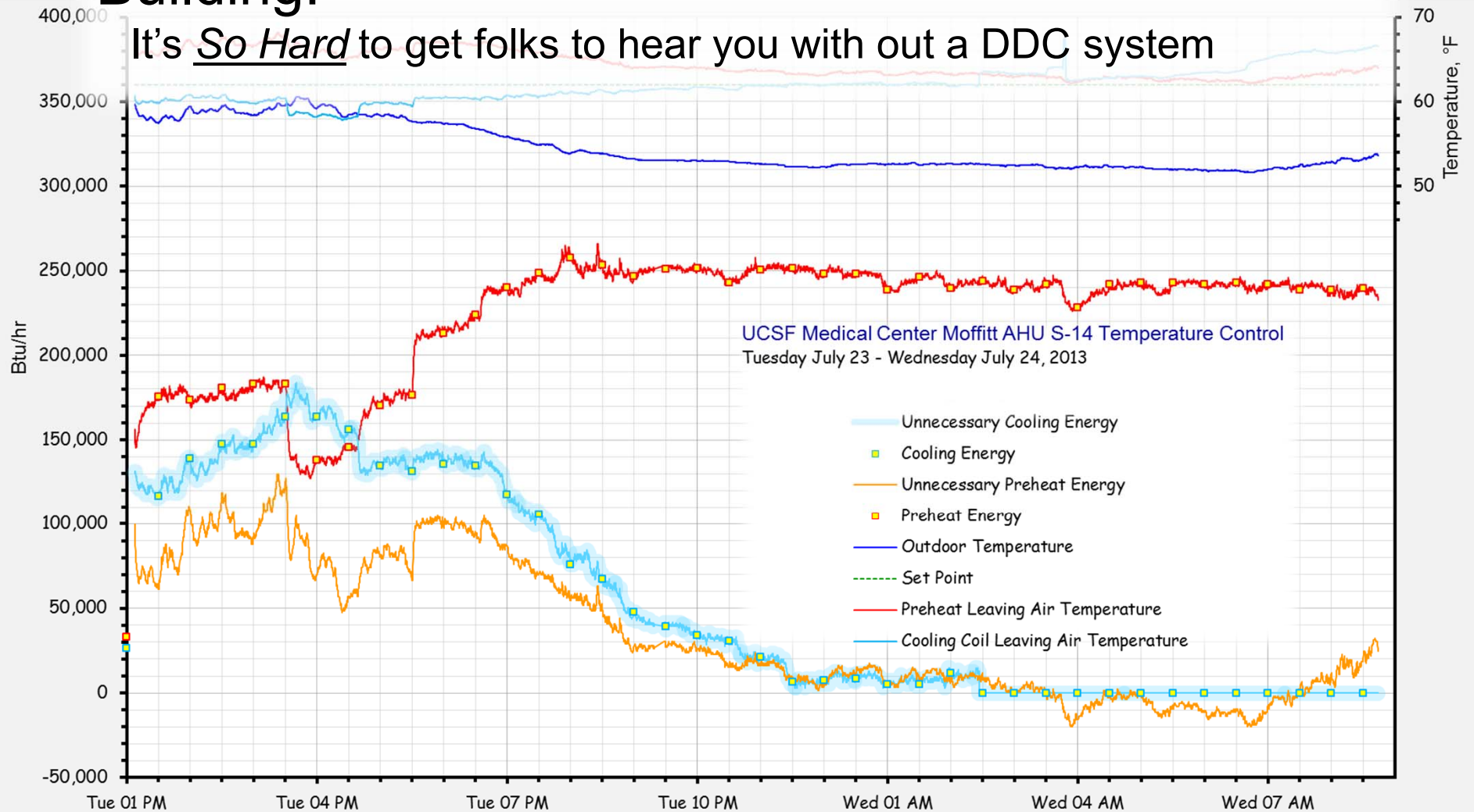
You:

Hmmm. Can we chat a bit?



Building:

It's So Hard to get folks to hear you with out a DDC system



You:

With a bit of time and maybe a bit more data, I suspect I can help you with that

#### Unnecessary Steam Use and Cost Per Day

Steam consumption per day based on the logged data -	4,530,371	Btu per day		
-	4,788	pounds of steam per day		
-	199	pounds of steam per hour		
-	\$99	per day		
-	\$4.11	per hour		
Gas input at the plant -	5,662,964	Btu per day		
-	57	therms per day		
Approximate annual savings potential based on bin data -	Low End	High End		
	426,029	852,058	pounds of steam per year	
	\$8,772	\$17,543	\$ per year	

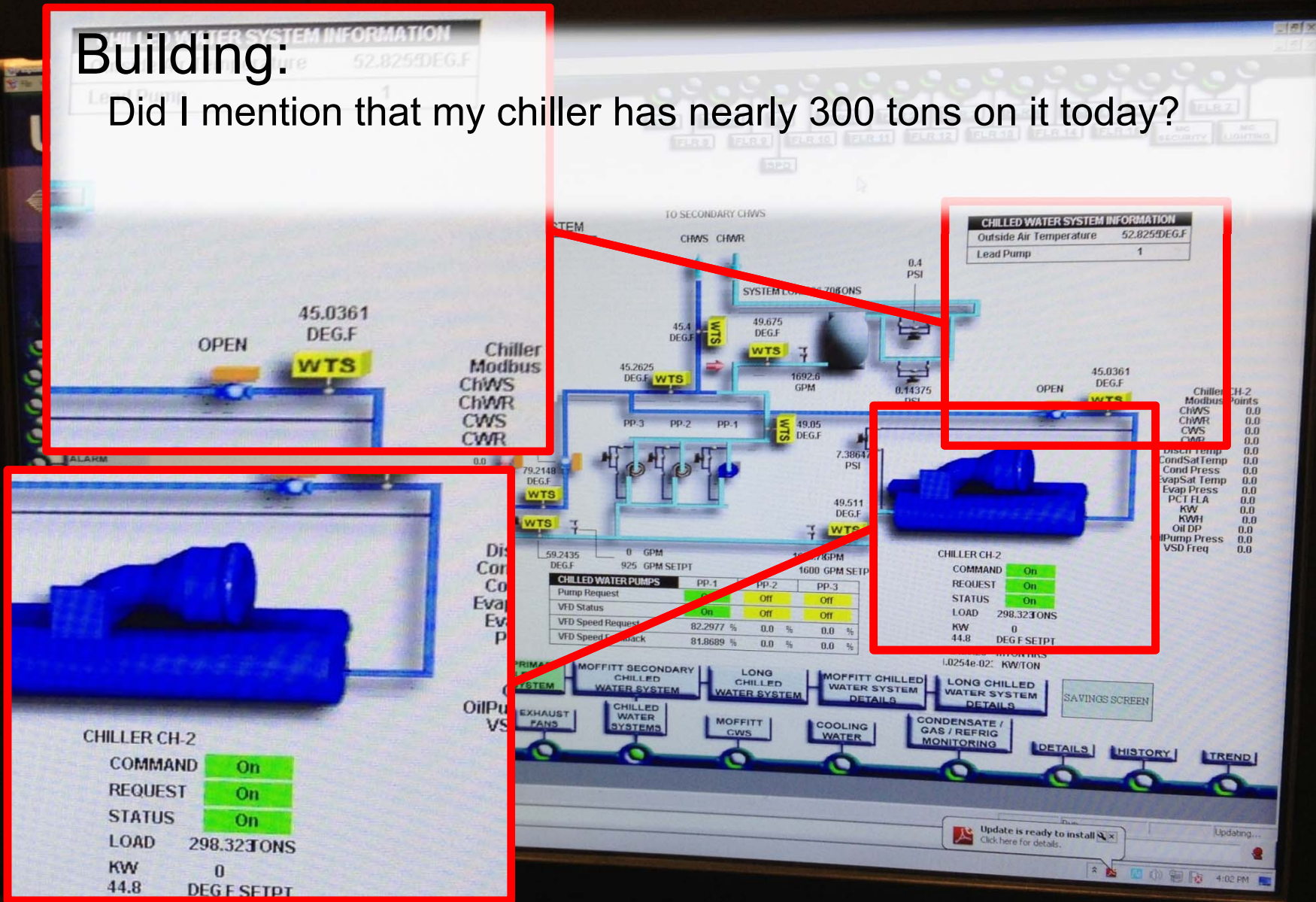
#### Unnecessary Chilled Water Use and Cost Per Day

Chilled water consumption based on the logged data -	113	ton-hours per day		
-	96	kWh per day at the assumed net plant efficiency		
-	4	kWh per hour		
-	\$11	per day		
	\$0.45	per hour		
Approximate annual savings potential based on bin data -	Low End	High End		
	8,523	17,046	kWh per year	
	\$966	\$1,933	\$ per year	



Building:

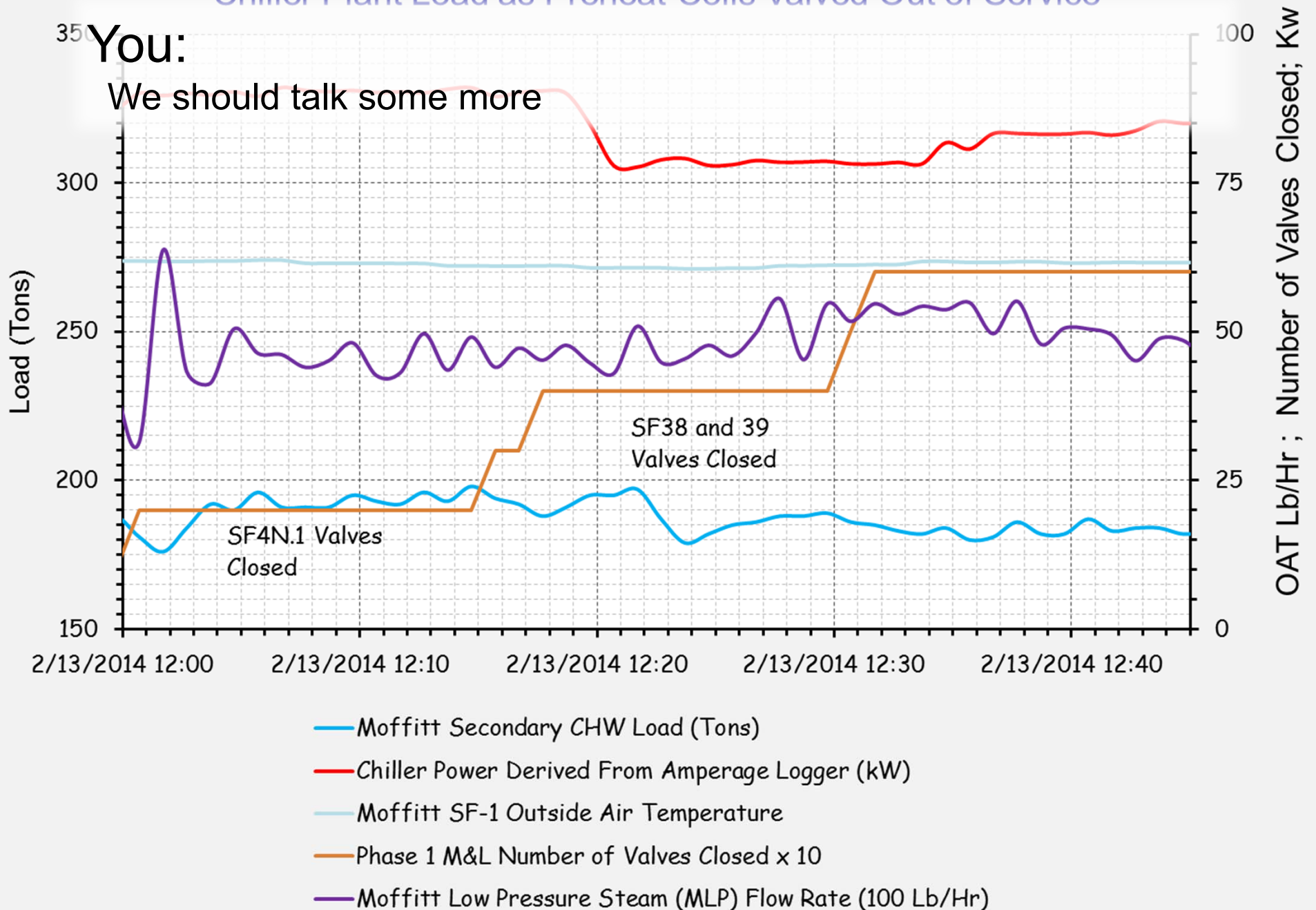
Did I mention that my chiller has nearly 300 tons on it today?



## Chiller Plant Load as Preheat Coils Valved Out of Service

You:

We should talk some more





# The Bottom Line

## Cost/Benefit Summary - Recommended Option

Main AHU Controls Plus 2 Token Zones per System Upgrade Costs -			\$542,165	Units Included:		
Savings:			Dollars	Energy	Wing A	Wing B
Wing B Electricity Savings -			\$53,819	484,856	SF-9 thru 13 SF-5.3	SF-10
Wing B Steam Savings -			\$34,428	1,831	SF-14 SF-23	SF-38
Wing A Electricity Savings -			\$29,954	269,852	SF-15 SF-5.4	SF-14
Wing A Steam Savings -			\$222,784	11,850	SF-25 SF-5.5	SF-15
Total Savings -			\$340,984		SF-1	SF-39
Potential Electrical Incentive -			\$181,130		SF-2	
Potential Thermal Incentive -			\$171,018			
Simple payback (before incentive) -			1.6	years (Construction cost basis for comparison to the other options)		
Owner Soft Costs -			\$189,758			
Project Budget with Owner Soft Costs -			\$731,923			

## Cost/Benefit Summary - Recommended Option

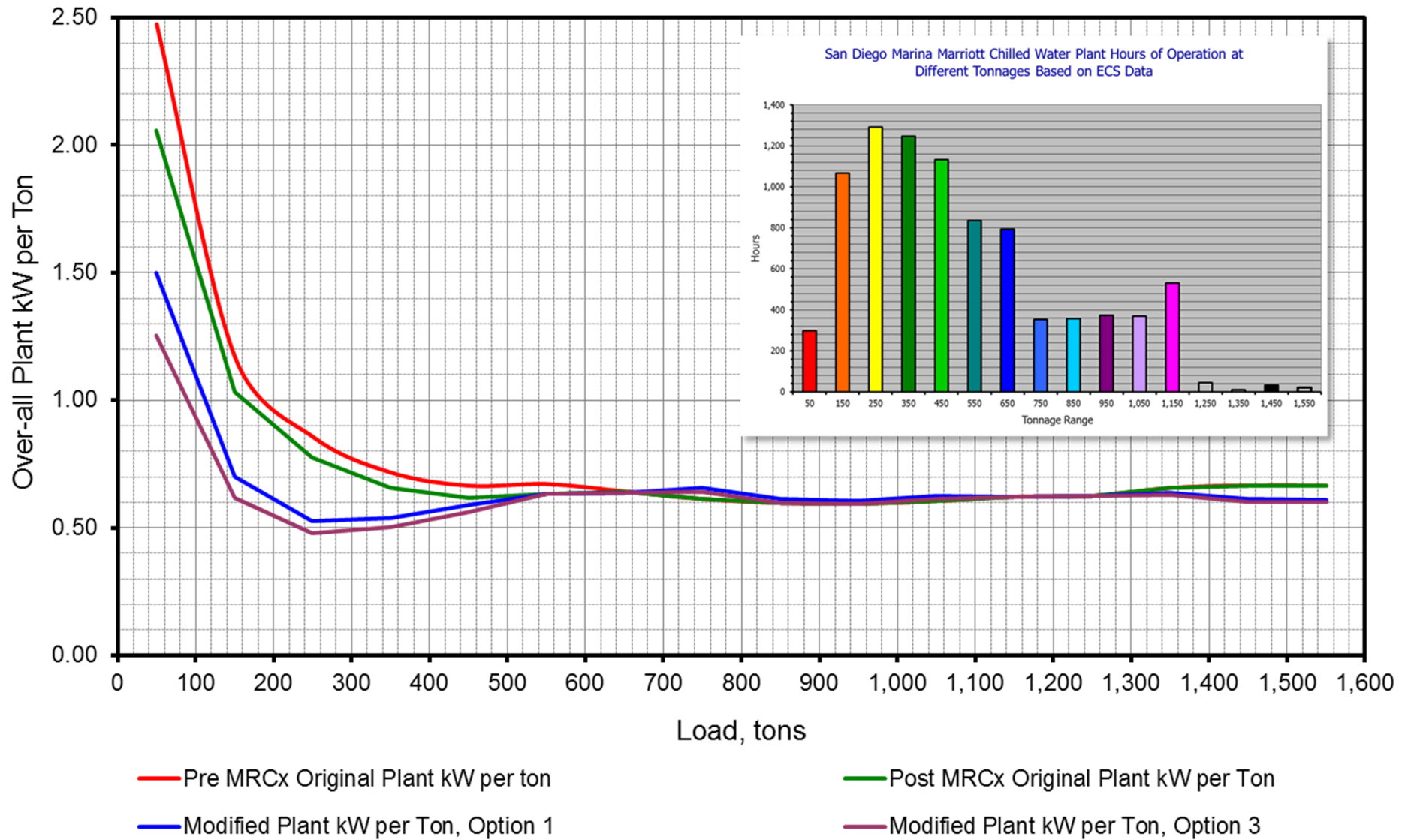
Main AHU Controls Plus 2 Token Zones per System Upgrade Costs -			\$542,165
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Total Savings -			\$340,984
Potential Electrical Incentive -			\$181,130
Potential Thermal Incentive -			\$171,018
Simple payback (before incentive) -			1.6 years (Construction cost basis for comparison to the other options)
Owner Soft Costs -			\$189,758
Project Budget with Owner Soft Costs -			\$731,923
Total potential Incentive -			\$352,148
Project Cost after Incentive -			\$379,774
Simple payback (after incentive) -			1.1 years
Avoided tonnage/installed chiller purchase cost for the Wubg B chilled water plant project -			96 \$671,293

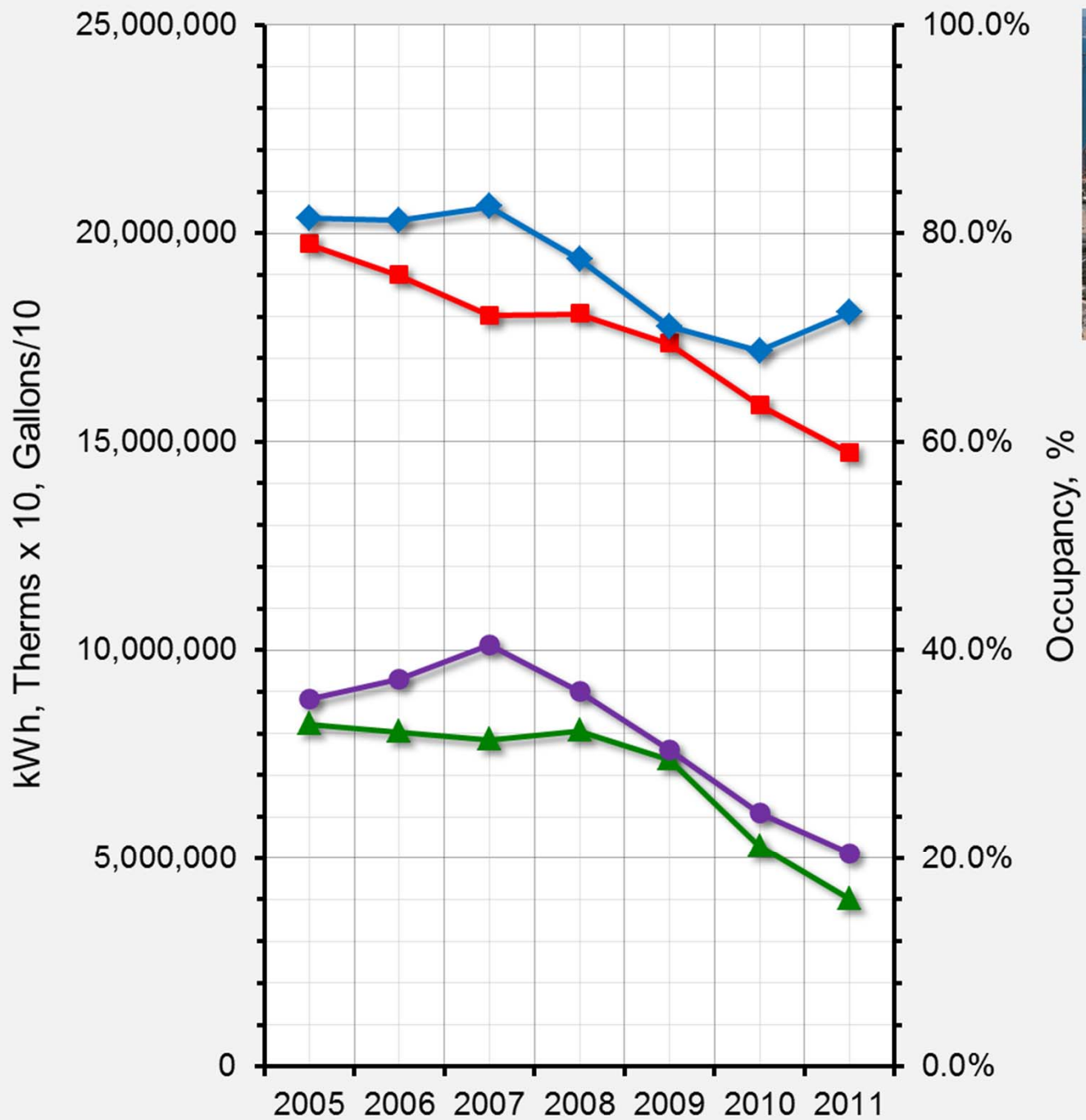
# The Bottom Line

*Commissioning is a process during which buildings mentor us about our designs*

## Over-all Plant kW per Ton

Compressor plus Condenser and Evaporator Pumps plus Towers





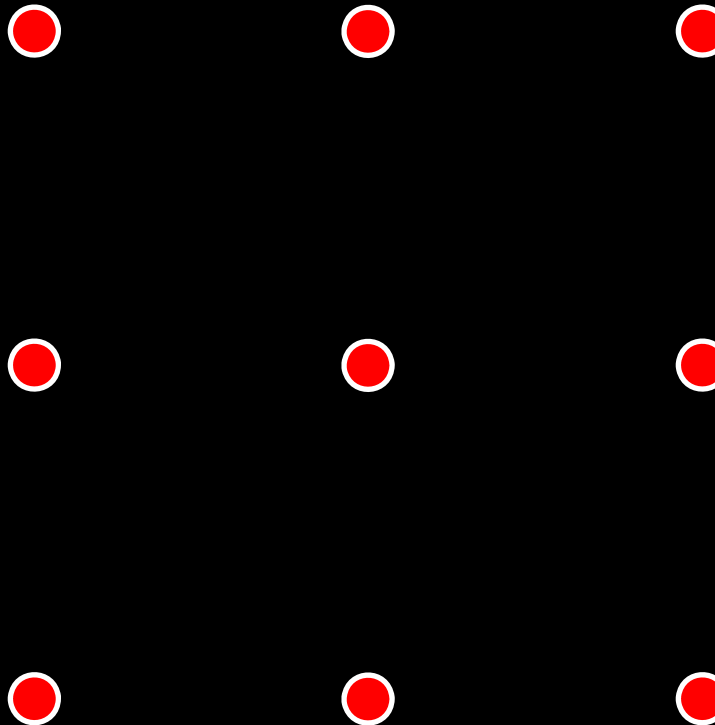
- Total kWh
- ▲ Total Gas, Therms x 10
- Water, gallons/10
- ◆ Average Occupancy

## San Diego Marriott Marquis and Marina

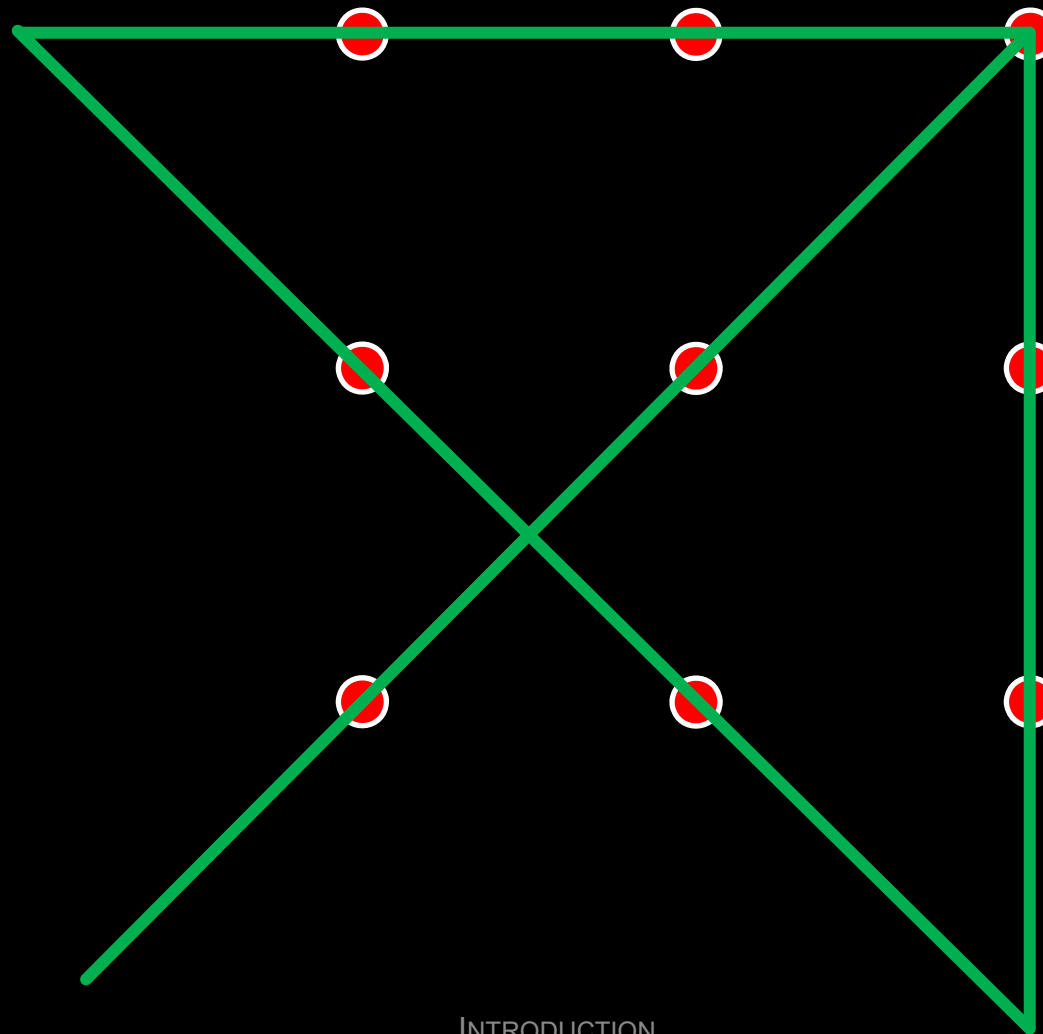
Utility Consumption

# A Puzzle

*Connect all of the dots  
with 4 straight lines  
with out lifting your  
pencil and with out  
retracing a line*



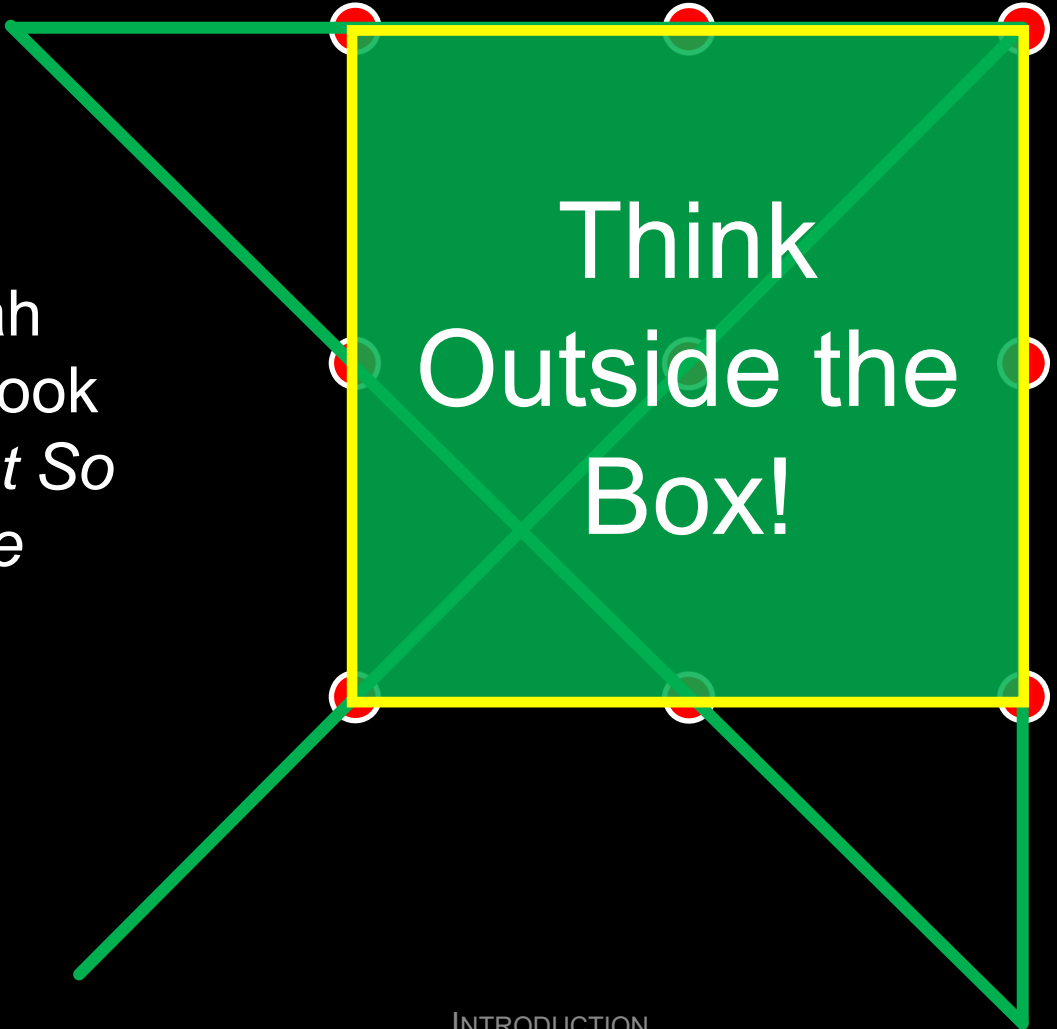
# A Puzzle





# A Puzzle

From Sarah  
Susanka's book  
titled *The Not So  
Big House*



Think  
Outside the  
Box!

*We can't solve problems by using the same kind  
of thinking we used when we created them*

Albert Einstein

In a highway service station  
Over the month of June  
Was a photograph of the earth  
Taken coming back from the moon  
And you couldn't see a city  
On that marbled bowling ball  
Or a forest or a highway  
Or me here least of all

*Joni Mitchell*  
*Refuge of the Roads*



*Image Courtesy William Anders, Apollo 8, 1968 NASA*

INTRODUCTION

## My Observations:

1. Only one “marbled bowling ball” in the near vicinity
2. We are all in this together
3. We need to start thinking and acting that way
4. The RCx skills you learn and apply can make a difference



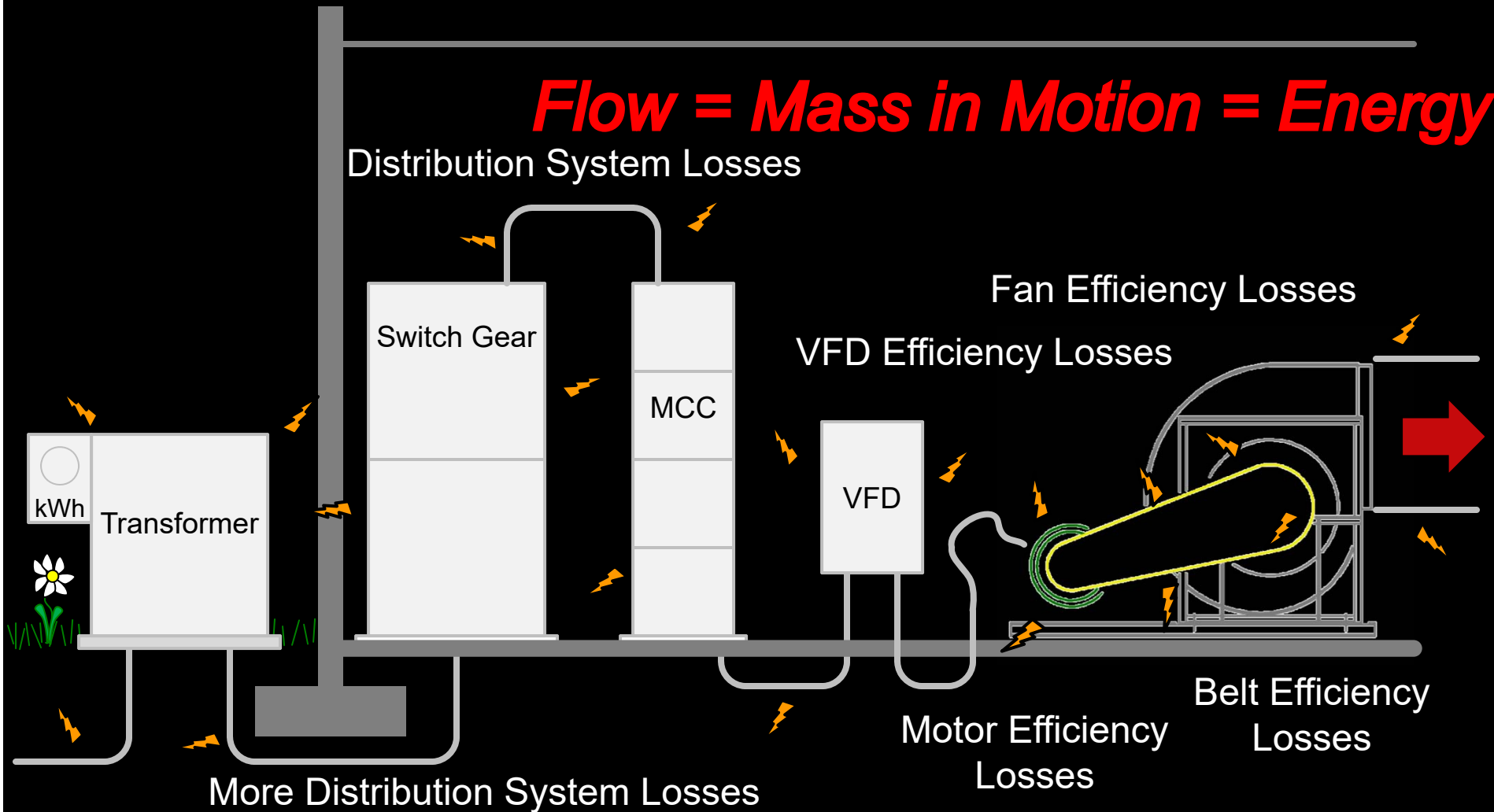
*Image Courtesy William Anders, Apollo 8, 1968 NASA*

INTRODUCTION

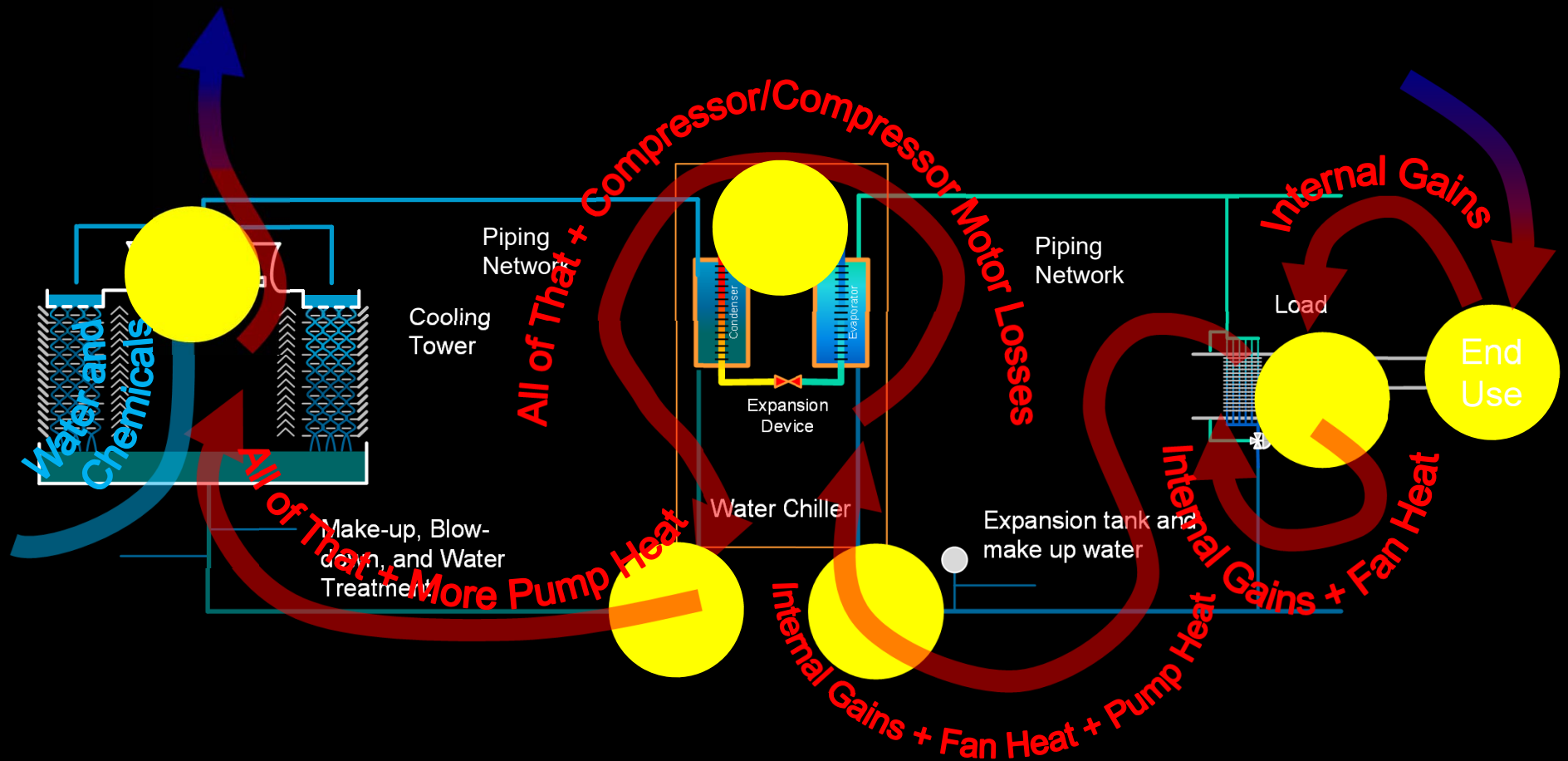
# The Difference is Bigger Than It May Seem

***Flow = Mass in Motion = Energy***

Distribution System Losses



# The Difference is Bigger Than It May Seem







My Logic Based Conclusion;  
We Have to be Having Some Sort of Impact

*Public Domain Image Courtesy <http://spaceflight.nasa.gov/gallery/images/station/crew-30/html/iss030e015721.html>*



You Also  
are Here

# Bottom Lines

*You can have a positive impact that is even bigger than you might have imagined*

- Existing buildings are full of opportunities to save energy and other resources and improve performance
- The 10 Key Retrocommissioning Skills can help you:
  - Identify the opportunities
  - Identify the savings potential they represent
  - Identify the steps required to capture the savings
  - Verify that the savings have been achieved
  - Ensure that the savings persist
  - Open the door to additional opportunity

## Bottom Lines

*You can have a positive impact that is even bigger than you might have imagined*

- Existing buildings are full of opportunities to save energy and other resources and improve performance
- The 10 Key Retrocommissioning Skills can help you:



- Make the world a better place and have a good time doing it